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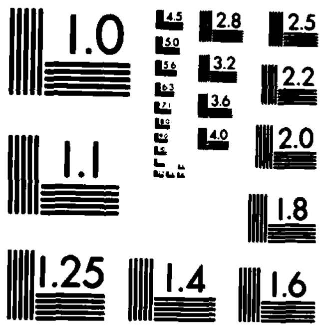

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ARCHAEOLOGICAL INVESTIGATIONS ON THE SAN ANTONIO TERRACE, VANDENBERG AIR FORCE BASE, CALIFORNIA, IN CONNECTION WITH MX FACILITIES CONSTRUCTION

Prepared by:

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Prepared for:

THE DEPARTMENT OF THE ARMY
Corps of Engineers, Los Angeles District
300 North Los Angeles Street
Los Angeles, California 90053

in Partial Fulfillment of
Contract No. DACA09-81-C-0048

January 1984

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This report presents the results of archaeological research undertaken in support of the Construction of MX missile test facilities on northern Vandenberg Air Force Base, Santa Barbara County, California. During 1980-1982, all lands potentially subjected to construction impacts (the project area) were surveyed, and test excavations took place at 24 sites in order to define their boundaries and assess their significance. At eight of these sites excavations were more intensive in order to collect additional information on site significance and to mitigate

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mitigate unavoidable impacts.

In addition to presenting the results of the analyses of the different classes of items in the collections, the report includes interpretations of the place of the sites in regional subsistence-settlement systems. All sites investigated appear to have been used by the Purisimeno Chumash Indians and their prehistoric predecessors within the last 2,000 years as seasonal residential bases or short-term occupation sites. Hunting terrestrial game appears to have been the dominant activity undertaken in the project area, as reflected in the high proportions of chipped stone artifacts in the site collections. Although a two-part chronological sequence for the sites is not firmly grounded, there is evidence indicating that the earlier inhabitants of the project area were relatively more mobile in their settlement pattern than the later inhabitants.

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ABSTRACT

This report presents the results of archaeological research undertaken in support of the construction of MX missile test facilities on northern Vandenberg Air Force Base, Santa Barbara County, California. During 1980-1982, all lands potentially subjected to construction impacts (the project area) were surveyed, and test excavations took place at 24 sites in order to define their boundaries and assess their significance. At eight of these sites excavations were more intensive in order to collect additional information on site significance and to mitigate unavoidable impacts.

In addition to presenting the results of the analyses of the different classes of items in the collections, the report includes interpretations of the place of the sites in regional subsistence-settlement systems. All sites investigated appear to have been used by the Purisimeno Chumash Indians and their prehistoric predecessors within the last 2,000 years as seasonal residential bases or short-term occupation sites. Hunting terrestrial game appears to have been the dominant activity undertaken in the project area, as reflected in the high proportions of chipped stone artifacts in the site collections. Although a two-part chronological sequence for the sites is not firmly grounded, there is evidence indicating that the earlier inhabitants of the project area were relatively more mobile in their settlement pattern than the later inhabitants.

PREFACE

In recent years, archaeologists interested in the ecological adaptations of hunter-gatherers have been working on the problem of how the archaeological record may be used to study subsistence-settlement systems. One approach to this problem has been to develop models or theories regarding the manner in which subsistence and settlement articulate with the distribution and abundance of food resources in order that predictions of the nature of subsistence-settlement systems may be made. A complimentary approach has been to develop or improve archaeological measures of different aspects of aboriginal subsistence and settlement. The research reported here attempts to take advantage of recent advances in both approaches to hunter-gatherer research.

This study also attempts to break new ground by utilizing portions of the archaeological record most neglected by archaeologists. For the most part, archaeologial research on hunter-gatherer subsistence-settlement systems has focused on the larger sites containing relatively dense cultural remains, while small sites with few remains have seldom been studied. As a result, much is known about sites occupied over substantial portions of the year or used intermittently over many hundreds of years to carry out activities that produce large volumes of imperishable debris, but little is known about short-term occupation sites at which few debris-producing activities took place. The contributors to this volume hope that they have demonstrated not only the importance of small, ephemeral sites to understanding the nature of subsistence-settlement systems, but also how useful information on subsistence and settlement can be gleaned from them.

The staff of the Vandenberg MX Archaeological Project and the contributors to this volume wish to extend their gratitude to the large number of people who provided help, services, or expertise during the course of the project. Without their aid, the project could never have reached a successful conclusion. During the course of fieldwork, a large number of individuals connected with the Strategic Air Command on Vandenberg Air Force Base provided assistance in logistics, expertise concerning base operations and environmental characteristics, and access to a variety of informational sources. Air Force personnel and contractors involved with the construction of MX test facilities also aided in facilitating the fieldwork and other aspects of the research.

Corps of Engineers archaeologists overseeing the Vandenberg MX Archaeological Project included Patricia Martz, Nancy Farrell, and Helen Wells. Their understanding and appreciation of the archaeological investigations was

fundamental to the success of the project, as was their coordination of logistics during all phases of fieldwork. The transfer of the archaeological project from the firm Henningson, Durham, and Richardson (HDR) to Chambers Consultants and Planners (CCP) was facilitated through the cooperation of the HDR personnel. Steven Craig and Michael Macko were especially helpful in this regard. Craig ultimately joined the CCP research team and was therefore especially instrumental in providing continuity between archaeological contractors.

E. A. Jackson, Jr., of VTN Consolidated, Environmental Sciences Division, aided in arranging the transfer of archaeological collections and related data derived from VTN's construction monitoring program to CCP for analysis. The VTN archaeological team undertaking the construction monitoring, headed by Laurence Spanne, deserve special thanks for their conscientious work and sharing of information through the course of MX test facilities construction.

The CCP project staff wishes to acknowledge the diligent efforts of all field, laboratory, and office personnel employed on the project. Their names, too many to mention here, are listed at the end of this report. Special recognition is extended to Linda Brown, who filled in as a laboratory director in the absence of JoAnn Kvamme, and Jack Zahniser, who as project manager prior to his leaving CCP for health reasons, helped keep the project on course throughout the fieldwork phase of the project.

The cooperation of the Santa Ynez Indian Reservation in arranging for Native American participants and monitors is also greatly appreciated. Juanita Centeno's efforts at coordinating relations with the Native American community are especially noteworthy.

Several individuals were particularly helpful in the data compilation and analysis. William Harris of Santa Barbara Community College's Department of Earth and Planetary Sciences arranged for the loan of a soils shaker and sample splitter used in processing soil samples. Robert S. Gray of the same department of the College identified a whale bone found during investigations. Lavern Hoffman, a hydraulic engineer with the County of Ventura, helped solve problems encountered during the soils analysis and provided expertise regarding water table fluctuation on the San Antonio Terrace and the formation of red soils. John R. Johnson of the University of California, Santa Barbara, (UCSB) Department of Anthropology provided advice on matters relating to collections curation. Larry R. Wilcoxon, manager of the State Office of Historic Preservation's Regional Information Center located at UCSB, provided access to Santa Barbara County archaeological site record files and helped resolve problems associated with San Antonio Terrace site records.

The Office of Public Archaeology at UCSB served as a subcontractor in the development of the project research design and in the analysis of specialized aspects of the collections. Their cooperation in meeting the goals of the archaeological project is greatly appreciated. The collections analysts

working through the Office of Public Archaeology, Bamforth, Hudson, and Serena, wish to acknowledge the support of the Office's staff through the course of their analyses and report preparation.

George L. Batchelder of Pollen Research Associates carried out a thoughtful study of the potential of palynological applications to the research. His enthusiasm for the research and responsiveness to project needs are appreciated.

D. L. Johnson, who carried out the soils and geomorphology study reported in Chapter 4, wishes to acknowledge a variety of individuals who aided in his research. Members of his family, Diana, Jenny, and Katie Johnson helped in different aspects of the fieldwork and in counting and measuring thousands of stones and concretions of soil samples. Rod Brown, who carried out a closely related study of the effect of dune activity on the archaeological record, exchanged ideas and provided invaluable help and a variety of information during the research. Michael Benedict of the Sanford and Benedict Winery provided information on pocket gopher activity in his vineyards, and Larry Signorelli of Lompoc provided access to his pocket gopher-turbated field. Thomas Rockwell and Rick Zapeda helped in the fieldwork and were a source of ideas invaluable to the research. Paul Collins aided in the identification of rodent species, and Ralph Philbrick and his colleagues at the Santa Barbara Botanic Garden provided information on native vegetation. Wayne Wendland of the Department of Geography at the University of Illinois analyzed tree ring samples from oaks on the San Antonio Terrace. Leon Follmer and Sue Wickham helped in pit digging and counting of concretions. HDR archaeologists Michael Macko and Steven Craig and VTN archaeologist Jon Erlandson provided a variety of help in project planning. Rainer Berger of the UCLA Radiocarbon Laboratory performed the radiocarbon dating associated with the research, and historian Lois Roberts and her husband provided information on historic land use of the San Antonio Terrace. The City of Lompoc and its citizens provided information relevant to the fieldwork. Barbara Bonell and the Department of Geography of the University of Illinois were responsible for typing the report and other help.

J. Serena also wishes to single out several individuals who aided his analysis of shellfish remains. Rod Brown served as guide during a field visit to the San Antonio Terrace, and he provided useful information on the local prehistory. JoAnn Kvamme was of invaluable help in organizing the collections and associated records prior to transfer to UCSB for analysis. Jim Consler and Brian Haley conducted much of the initial analysis of the shellfish remains and provided information useful in planning the analysis. Douglas Bamforth shared his ideas regarding subsistence and settlement on the San Antonio Terrace that were helpful in interpreting the shellfish data.

In order to protect the sites mentioned in this report, specific locational information has been omitted from verbal descriptions of sites and from all maps. Those individuals with legitimate needs for this information may contact the Regional Information Center in the Department of Anthropology, University of California, Santa Barbara.

Chapter 1

INTRODUCTION

PURPOSE OF THE ARCHAEOLOGICAL INVESTIGATIONS

The archaeological investigations reported herein were undertaken in response to the construction of MX missile test facilities in a portion of northern Vandenberg Air Force Base containing a high density of archaeological sites. The bulk of the investigations were carried out in an effort to locate archaeological resources so that proposed construction could be planned or adjusted to avoid impacting them. In the relatively few instances in which construction would have unavoidable impacts, investigations were carried out first to obtain data sufficient for assessing the significance of archaeological resources in terms of criteria for inclusion in the National Register of Historic Places, and then, if the resources were deemed significant, to collect data sufficient to mitigate the construction impacts.

An important aspect of the Vandenberg MX Archaeological Project was to carry out these investigations within the context of ongoing construction in such a way as to minimize delays to construction when archaeological investigations were required. Because of the extremely short time between the initial planning of the MX missile test facilities and the initiation of construction, archaeological assessments and mitigation of impacts could not be accomplished prior to the inception of construction.

From a research standpoint, the MX Archaeological Project provided an opportunity to increase knowledge of the prehistory of a poorly known region of coastal California. Fortuitously, the project complemented the investigations recently carried out on the southern portion of Vandenberg Air Force Base in connection with construction of Space Transportation System (i.e., Space Shuttle) facilities (Glassow et al. 1981). However, while these latter investigations focused on prehistoric habitation sites containing substantial quantities of midden debris, the MX Archaeological Project principally involved sites of short-term occupation and little or no accumulation of midden debris. Consequently, the data from the two projects taken together provide a much more rounded picture of the variability in the archaeological record of the Vandenberg region.

The project also afforded the chance to study the archaeology of one of the most distinctive environments along the California coast. The greater part of the project area falls within an extensive stabilized coastal dunefield, and soils of the archaeological sites typically are comprised of unconsolidated sand. From the onset of the research, it was hypothesized that the unique

character of this coastal dunefield would have had considerable influence on the kinds of prehistoric activities that transpired in the project area and the character of the archaeological record. Furthermore, since the stabilized dunes retain the topographic features of active dunes, it was suspected that they were formed relatively recently, perhaps during the mid-Holocene, and that their subsequent stabilization was related to a significant climatic change. If such a change did occur, it would undoubtedly have affected prehistoric land-use patterns.

DESCRIPTION OF THE PROJECT AND STUDY AREAS

Vandenberg Air Force Base lies along a 60 km stretch of coastline which is predominately south-facing along the southern quarter and predominantly west-facing along the northern three-quarters (Figure 1-1). The southern boundary of the base is at Jalama Beach, about midway between Point Conception and Point Arguello. The northern boundary is near Point Sal. This whole coastline is exposed to the prevailing northwest winds, although the bights formed by Point Sal, Purisima Point, and especially Point Arguello are somewhat more protected. In the vicinity of these three points, the shoreline is rocky, providing an ideal habitat for a variety of intertidal marine organisms. Between the points, the shoreline is straight and sandy, and intertidal marine life is considerably less dense. Because the Vandenberg coast is exposed to strong onshore winds and the southward-moving California Current, surf is generally heavy, and coastal fogs prevail over much of the year and are especially prevalent during the summer. Rainfall along the Vandenberg coast is somewhat lower than in regions to the north and south, averaging 12.25 inches (31 cm) per annum as recorded at nearby Santa Maria (Wallis 1977).

Four major coastal drainages cross Vandenberg. Shuman Canyon, near the northern edge of the base, and Honda Canyon, near the southern edge, are only about 12 km long, whereas San Antonio Creek is about 45 km long, and the Santa Ynez River extends 120 km into the mountainous interior of the Transverse Ranges. The valley of the Santa Ynez River forms a division between the western terminus of the Santa Ynez Mountains, to the south, and the lands of low relief covering the northern part of Vandenberg to the Casmalia Hills and the Purisima Hills. Elevations above sea level on south Vandenberg have maximums between 365 and 658 m, and on the northern edge of Vandenberg the highest hills vary between 275 and 500 m.

Vegetation on Vandenberg is strongly influenced by the onshore winds and fog, as well as by the sandy soils occurring in many parts of the base. Following the plant community classification of Coulombe and Mahrdt (1976), coastal strand vegetation occurs spottily on the recent and still active dunes near the coast, giving way to the dune phase of coastal sage scrub on stabilized dunes and to the normal and *Salvia leucophylla* phases of this community on well-drained slopes, especially where soils are well developed. A low-growing chaparral covers older dune soils away from the coast, and

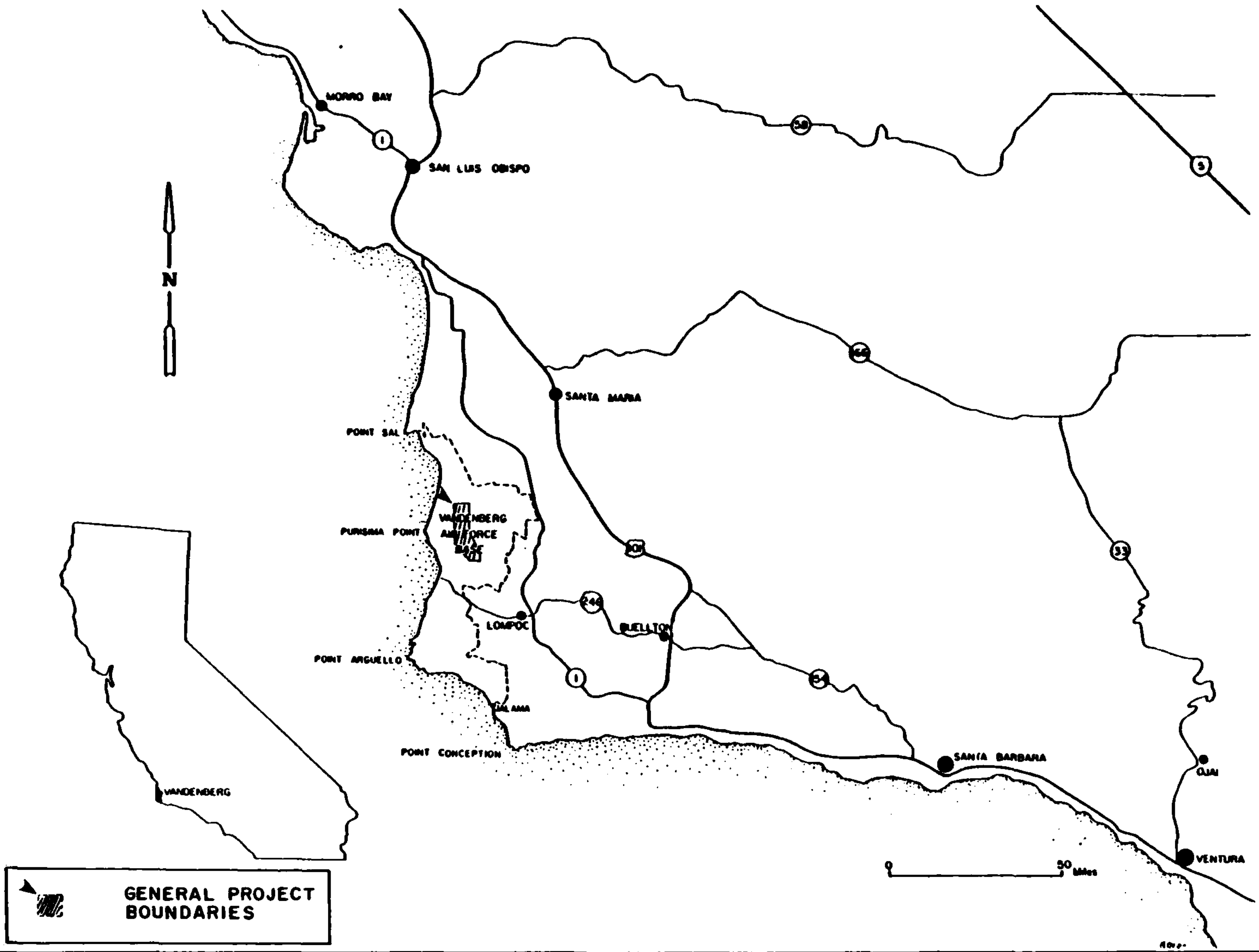

Figure 1-1. Vandenberg Air Force Base with General MX Missile Archaeological Project Area Indicated.

grasslands mixed with annuals are often found on well-developed silty soils. Woodlands and forests of Bishop pine exist in more protected environments away from the coast where sandy soils are present, and foothill woodlands containing oaks in varying densities are found in protected spots on a variety of soil types. Except for very small and widely scattered patches, woodlands do not occur within about 5 km of the coast. Riparian woodlands occur next to the streams and on adjacent bottom lands, as well as in the wetter swales in the dunefields.

Of these communities, grasslands, foothill woodlands, and riparian woodlands would have been most important to aboriginal settlement as sources of plant and animal foods, fuel, and raw materials. In addition, chaparral and the coastal sage scrub communities, which cover extensive areas of the base, would have been important as habitats of the larger game animals, especially deer (Coulombe and Mahrdt 1976:175).

Because of the relatively low level of land development on Vandenberg, native mammals are abundant and widespread in their distributions. The larger mammals most likely to have been important aboriginal food sources include mule deer, jack rabbit, and two species of small rabbits. A wide variety of rodents is also abundant in most habitats. Sea mammals, including the California sea lion, Steller's sea lion, and harbor seal, are documented to be in the offshore waters (Coulombe and Cooper 1976:131-135) and would have been accessible to aboriginal populations at haul-outs along rocky shores.

The MX missile test facilities have been placed in an area of north Vandenberg known as the San Antonio Terrace. More properly, this landform is a set of low-relief terraces extending southwest from the Casmalia Hills (see Chapter 4) to the San Antonio Valley. On the north, at the foot of the Casmalia Hills, the San Antonio Terrace is bounded by Shuman Canyon. North to south, the terrace extends about 6 km, and from the Pacific Ocean eastward to the Casmalia Hills, it extends about 10 km. Much of the terrace is covered by a mantle of dune deposits of varying ages, which are described in detail in Chapter 4. The most recent are the "modern" (historic) dunes, generally within about a kilometer of the coast. These are largely unvegetated and are presently quite active. Beyond these and extending a maximum distance inland of nearly 6 km, are the "intermediate" dunes (i.e., intermediate in age). These have been relatively stabilized by a cover of coastal sage scrub of the dune phase (also called "dune scrub" or "backdune scrub" [HDR 1980]). Underneath and inland from the intermediate dunes are the "old" dunes, which have lost much of their dune profile and are covered with dune phase coastal sage scrub that differs somewhat in species composition from, and is denser than, the scrub covering the intermediate dunes. (This community variant is called "mesic scrub" [HDR 1980]). Two other dune units, referred to in Chapter 4 as "older" and "ancient," are found at higher elevations along the eastern margin of the terrace and into the Casmalia Hills. These support a variety of plant communities, including the coastal sage scrub variant just mentioned, foothill woodlands, chaparral, and some grasslands.

The extensive intermediate dunes give the San Antonio Terrace a very distinctive character when compared to other portions of Vandenberg. Since the dunes still retain the pronounced topography of their formation, numerous swales exist between the dune ridges, and many of these have sufficiently high water tables to produce wetlands containing vegetation that in other parts of Vandenberg would be designated riparian. The only other area on Vandenberg with well developed intermediate dunes is along a narrow coastal strip from the southern edge of the Santa Ynez Valley south to Honda Canyon. This belt of coastal dunes is so narrow that it does not provide as pronounced a contrast between dune ridges and wetlands.

For purposes of this report, a distinction is made between "project area" and "study area." The former is comprised of all those lands that were subject to investigations under the Vandenberg MX Archaeological Project (Figure 1-2). As such, it includes property within and immediately adjacent to actual or proposed construction zones. The study area, on the other hand, is a unit of land that includes most of the San Antonio Terrace, as well as an outlier to the south where the project area extends onto Burton Mesa. The northern boundary of the study area is Point Sal Road, which runs along the northern margin of Shuman Canyon. The southern boundary is the southern edge of the San Antonio Valley bottomlands and the Lompoc-Casmalia Road, including a strip of land extending about 5.5 km southeastward on either side of 13th Street to the Western Space and Missile Center building. The western boundary is the Pacific Ocean, and the eastern boundary is the eastern edge of the survey corridor along the 69 KV power line and the northernmost leg of Lompoc-Casmalia Road.

Because the project area is dictated by the locations of proposed and actual construction activities, its boundaries are very complex, consisting of irregularly shaped blocks of land with strips extending out from them along which roads were constructed and power and communications lines were emplaced. The 69 KV power line corridor is the only unconnected portion of the project area.

The creation of the study area was necessary for several reasons. First, because of the configuration of the project area, it is clear that the sites contained within it could not be argued to be representative of variability in sites in the local area. The biases in such a sample of sites simply could not be ascertained by focusing all analysis on these sites alone. In particular, the contexts of project area sites in prehistoric subsistence-settlement systems could not be understood without considering regional variability in sites. Second, it became apparent early in the archaeological investigations that sites had been affected by dune movement and that some sites might conceivably be buried under considerable depths of dune deposits. If the impact of dune movement on the project area sites was to be understood, the whole dunefield must be a unit of investigation. In a similar light, an understanding of environmental changes that affected the prehistoric inhabitants of project area sites requires consideration of the larger region, especially the area encompassed by the dunefield. Third, the

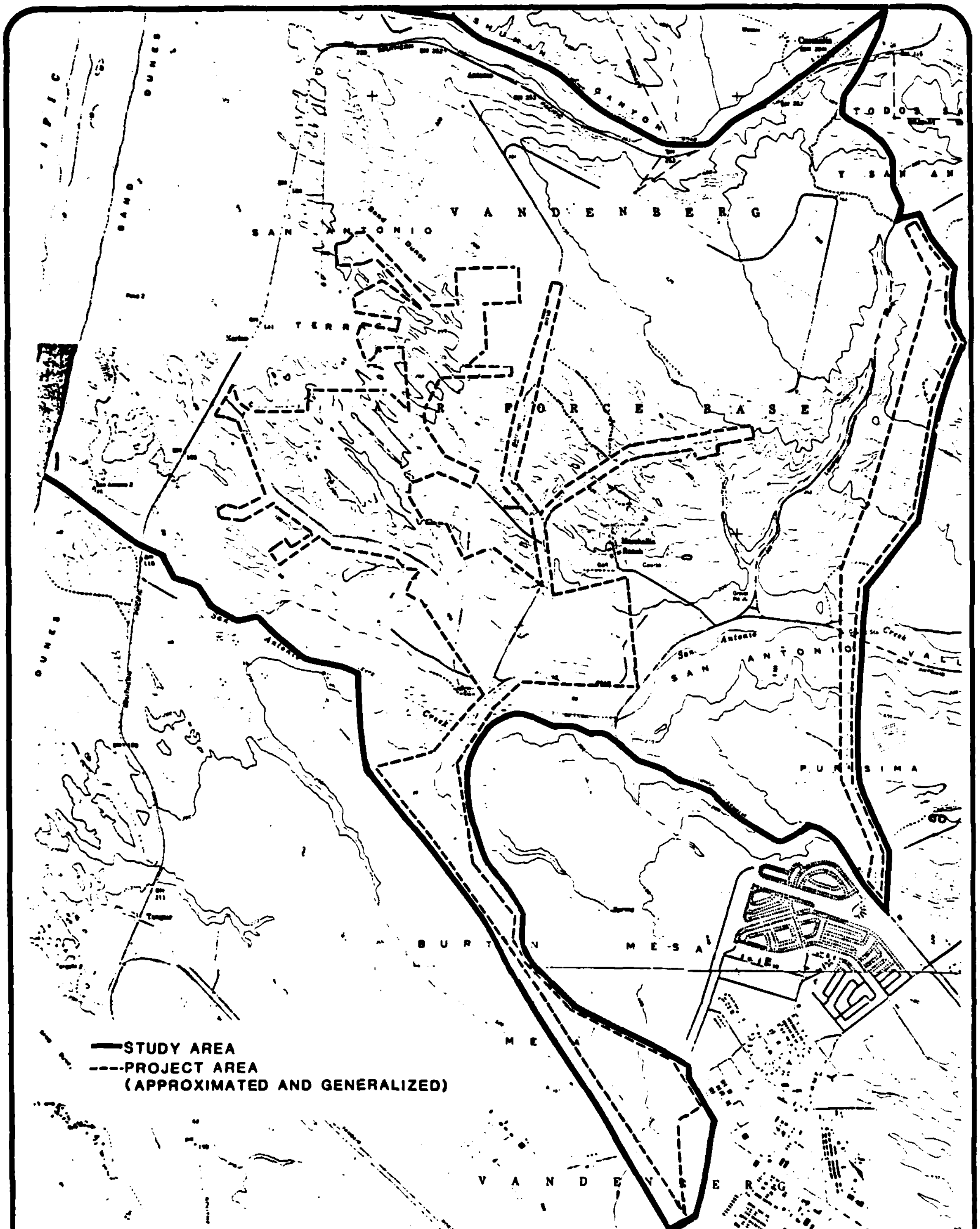

Figure 1-2. The MX Missile Study Area and Approximate Project Area U.S.G.S. Casmalia and Surf 7.5' Quadrangles.

ethnohistoric and historic overviews (Appendices I and II) by definition must take a regional approach; these were mandated by the No Adverse Effect Determination negotiated by the Air Force. It should be emphasized, however, that no archaeological investigations beyond casual survey took place beyond the bounds of the project area.

The definition of the study area as roughly coterminous with the San Antonio Terrace appeared to represent an optimal balance between the different research needs just mentioned and project requirements. Not only is this area relatively discrete environmentally, especially with regard to the processes of dune formation, but it appears to contain a diversity of previously recorded sites nearing the range of site diversity seen in the Vandenberg region as a whole.

PROJECT HISTORY

The Vandenberg MX Archaeological Project did not evolve in a way typical of Federal development projects of comparable scale. Because the planning and construction phases of the MX test facilities on Vandenberg were both quite short, with virtually no lag-time between them, there was not the opportunity to divide the archaeological program into temporally distinct phases of survey, tests for determining the significance of cultural resources, development of a research design for mitigating unavoidable impacts to cultural resources, and ultimately data recovery to mitigate the impacts. Instead, all of these activities had to occur simultaneously, and the archaeological staff often alternated between tasks assignable to the different phases mentioned above on a day-to-day or at best week-to-week basis.

Complicating the scheduling of archaeological activities was the problem that many sites in the intermediate dunes tended not to be readily identifiable or clearly defined through surface evidence. Since these dunes have been active to varying degrees up to the historic period, if not during the historic period as well, many sites have been covered with a mantle of wind-blown sand. The discovery in 1978 of a dense shell midden deposit under 15 m of comparably aged dune deposits on south Vandenberg (Glassow et al. 1981:8-11) made this problem especially worrisome. As a result, survey carried out later on during the project had to be supplemented by time-consuming subsurface testing, usually in the form of shovel-excavated holes excavated to depths between 50 and 100 cm (shovel test pits or STPs). Unfortunately, this procedure did not always successfully identify the presence of archaeological sites, as several were discovered during construction which required emergency mitigation of impacts.

Despite these problems, the archaeological project was largely successful in providing information on the locations and extents of sites so that avoidance or minimization of impacts to sites could be accomplished through revisions to the test facility site plan. Although the density of sites on the San Antonio Terrace is very high, only nine sites were discovered during construction activities, and excavations to mitigate unavoidable impacts of

construction were required at only four out of the total of 60 sites at which some sort of investigation (i.e., survey or testing to assess potential extent of impacts) was necessary.

Planning for the development of MX missile test facilities on Vandenberg had reached a point in 1978 that a draft environmental impact statement (USAF 1980) could be prepared which identified four prospective locations ("candidate siting areas") on the base where the facilities could be concentrated. Although the San Antonio Terrace was included as one of the four prospective locations, it was proposed that the facilities be sited on lands northeast of the area ultimately selected, completely off the intermediate dunes. In this study, it was recognized that cultural resources, particularly prehistoric sites, were known or expected to occur in all four areas, and it was predicted that some of the impacts to the sites would be unavoidable.

By mid-1979 a plan had been developed by Martin Marietta Corp. for siting the MX test facilities on San Antonio Terrace (Martin Marietta 1979). The locations of the different facilities had been specified to such a point that potential impacts to cultural resources could be determined, and feasible adjustments to facilities siting could be made in order to avoid impacts. These facilities are listed in Table 1-1. Since cultural resources were being considered in the context of environmental studies by the Santa Barbara office of Henningson, Durham, and Richardson (HDR), their archaeological staff was expanded in order to carry out the archaeological surveys necessary to determine potential impacts to archaeological sites. These surveys began in fall 1979 by a HDR team headed by Dr. William Doelle (who had prepared the archaeological elements in the 1978 draft EIS cited above), although the fieldwork at Vandenberg was directed by Steven Craig. Through the remainder of 1979 and in the first part of 1980 survey activities were intensive; howeve·, through most of 1980 surveys were carried out intermittently by the HDR field team primarily in response to plan changes and additions.

In the first months of 1980, HDR had accumulated sufficient field information to prepare a plan for carrying out evaluations of construction impacts on cultural resources and mitigations of unavoidable impacts (HDR 1980). This plan summarized all investigations carried out through March 1980, specified where unavoidable impacts were expected, made assessments of eligibility of sites for inclusion on the National Register of Historic Places, and proposed appropriate mitigation measures. This document led to a No Adverse Effect determination, which was issued by the Air Force in August 1980.

An important element of HDR's plan was a set of procedures for avoiding impacts to National Register eligible sites. Where feasible, the prospective locations of MX facilities were to be adjusted so as to avoid being placed on sites. Access roads were to follow existing road rights-of-way where appropriate routes existed, and improvements to these roads were to be limited to the previously disturbed road breadths. Similarly, the routes of new power communications lines were to follow previously used rights-of-way

Table 1-1. MX Test Facility Construction Components and Reference Abbreviations.

Facility	Abbreviation
Horizontal Test Structure (four)	TS-1 through 4
Integrated Test Facility	ITF
Test Pad (two)	TP-1 and 2
Mechanical Maintenance Facility	MMF
Missile Assembly Building	MAB
Payload Assembly Building	PAB
Rail Transfer Facility	RTF
Stage IV Installation & Checkout Facility	ICF
Stage Processing Facility (two)	SPF-A and B
Stage Storage Facility	SSF
Access roads	none
Construction access roads	none
69 KV power line	none
12.47 KV power line	none
Fiber-optics communication lines	FO
Cable communication lines	CL
Borrow Pits	none

if possible, including the shoulders of existing roads. These avoidance procedures were followed throughout the planning and construction phases of MX missile test facilities development.

Because certain construction projects scheduled to begin in early 1980 were recognized to have unavoidable impacts on archaeological sites, HDR subcontracted with the University of California, Santa Barbara, Office of Public Archaeology (UCSB-OPA) to carry out a series of subsurface investigations, first to identify the nature and extent of impacts and later to recover data as a mitigation measure. The UCSB-OPA field teams carried out mapping and, when necessary, shovel test pit excavations at sites in the way of construction access roads, a horizontal shelter, the MAB, and a new gatehouse at the El Rancho Lateral entrance to the base. Major mitigation excavations were completed at the MAB and the El Rancho Lateral gatehouse, as well as minor excavations at power pole locations along El Rancho Lateral Road. These investigations were the subject of a series of reports (Arnold 1980; Bixler, Ford, and Stone 1980; Duncan 1980a, 1980b; Ford 1980a, 1980b; Haley and Serena 1980; Snethkamp, Duncan, and Ford 1980a, 1980b) having the objective of describing the investigations and the gross nature of the data recovered. Data analysis was not part of the work since this was to be accomplished under separate subcontracts at a later date.

These early investigations, and the discovery of archaeological deposits during grading, testified to the difficulty of recognizing sites on the basis of surface indications alone. As a result, the HDR survey team began to include the excavations of shovel test pits (STPs) in order to define the boundaries of sites. Having developed a capability to carry out subsurface investigations, HDR decided in the fall of 1980 to end their relationship with UCSB and to undertake all aspects of the archaeological investigations with HDR personnel. During the fall and winter of 1980, therefore, the HDR team performed testing at six sites to be affected by construction of roads and the SPF-B. Mitigation excavations were undertaken where poles for new power lines were to be implanted and at a pair of sites to be impacted by a shelter access road.

This put the HDR archaeological team in the unique position of overseeing for the Air Force the archaeological investigations and at the same time actually undertaking these investigations. As a result of this potential conflict-of-interest, the archaeological staff at the Los Angeles District Office of the U. S. Army Corps of Engineers (COE) was brought in by the Air Force in late 1980 to review HDR's ongoing work and to coordinate the archaeological investigations with the construction schedule. For these purposes, a full-time COE archaeologist (Nancy Farrell) was stationed at Vandenberg until the end of earth-moving aspects of construction.

In December 1980, HDR decided that their firm should no longer be involved with the fieldwork at Vandenberg, and so COE took over full responsibility for the Vandenberg MX Archaeological Project. Before a new contractor to carry out the archaeological investigations could be obtained, the COE archaeological staff was obliged to carry out two days' fieldwork at

SBa-1718 in late December 1980 to complete the mitigation of impacts of imminent access road construction. (M. Glassow served as a field consultant for this work.) In January 1981, COE called in Chambers Consultants and Planners (CCP), with whom an open-end contract relationship was already established, to continue the field program. This action was necessary in order to obtain a contractor's services quickly. Steven Craig was brought over from the old HDR team to serve as co-principal investigator, and Michael Glassow became the principal investigator. Project management was placed in the hands of CCP's archaeologist, Jack Zahniser.

In the course of assuming management of the Vandenberg MX Archaeological Project, COE developed a plan for the cultural resources management program spanning the remainder of the project (USACOE 1980). This plan established an overall structure for the archaeological investigations consistent with the conditions of the No Adverse Effect Determination. It included management procedures to be followed by COE and a mitigation plan outlining measures to be carried out in an efficient and timely manner as cultural resources were encountered in construction zones.

In June 1981, after a competitive bidding process, COE awarded a second contract to CCP for the remainder of the project investigations. The investigations covered by the second contract were designated Phase II in order to differentiate them from those carried out under the initial contract. At the beginning of Phase II, Sheila Callison joined CCP's archaeological team as a co-principal investigator. She eventually took over many of Craig's responsibilities, who left the project during the summer of 1981.

An independent team of archaeologists, working under a contract awarded through separate channels by the Air Force to VTN Consolidated, monitored all earth-moving by heavy equipment which took place during the early stages of construction. The VTN team was headed by Laurence Spanne, an archaeologist who had been involved in different aspects of archaeology on the base since 1969. He and his assistants had the authority to stop temporarily the work of heavy equipment if archaeological materials were encountered. When this happened, Spanne and his assistants first carried out cursory field investigations in order to determine whether the materials were of sufficient quantity and density to justify designation as a "candidate archaeological site." If the archaeological finds were so designated, COE archaeologist Nancy Farrell was notified so that further evaluation of the candidate site could be made by archaeologists associated with the MX Vandenberg Archaeological Project. It should be noted that COE's plan for the cultural resources management program streamlined the communcation links between the monitoring and mitigation field teams. Prior to COE involvement, notification of archaeological finds by monitors formally reached the field team handling the mitigation through several tiers of bureaucracy, which slowed communication considerably.

From the beginning of construction in early 1980, isolated prehistoric items were encountered in approximately 50 separate instances, although only a few of these required temporary stoppages or diversion of earth-moving

equipment while VTN archaeologists checked out the finds. The VTN archaeologists also discovered nine candidate archaeological sites (one of which was actually discovered by HDR archaeologists). Three of these in the vicinity of the MAB were assigned site numbers and were subjected to testing and/or mitigation excavations by UCSB-OPA. Three others encountered along road rights-of-way were also assigned site numbers and subjected to subsurface investigations.

The monitoring of earth-moving construction activities by VTN archaeologists was therefore a valuable supplement to the other aspects of the archaeological investigations. Not only were previously unknown sites and isolated finds discovered, but more importantly, these were encountered in contexts which gave witness to the problem of locating archaeological sites in the intermediate dunes and the fact that not all archaeologial materials are concentrated at discrete loci normally designated sites. Since much of this information became available in the early stages of earth-moving by heavy equipment and near the beginning of the archaeological project, it had considerable influence on the design of the rest of the field work.

By October 1981 the bulk of the fieldwork connected with the archaeological project had been completed, and as a result, attention turned to the data analysis. The analysis of soil samples from sites was handled by CCP personnel at their Santa Barbara laboratory under the supervision of the principal investigator and laboratory director and consultation with soils geologist T. Rockwell. Other aspects of the data analysis were subcontracted to various individuals or institutions. Proposals from subcontractors for each aspect of the data analysis having been accepted by both CCP and COE, all of the subcontracts were let during the fall and winter of 1981 except for the analysis of lithics. Because of the special importance of this aspect of the analysis, CCP opened this subcontract to competitive bidding (the only subcontract so handled), and an award to UCSB-OPA, the successful bidder, was not able to be made until March 1982.

Two special field studies were undertaken after the completion of the archaeological fieldwork. The first of these was a pilot study to determine whether fossil pollen was sufficiently preserved in San Antonio Terrace wetlands to justify undertaking a full-scale study aimed at discerning paleoenvironmental change through prehistory. This study was performed during December 1981 under a CCP subcontract to G. Batchelder of Pollen Research Associates, Inc. Unfortunately, the results were not encouraging enough to proceed with a full-scale study (Batchelder 1982).

The second study focused on the geomorphology and soils of the San Antonio Terrace and surrounding regions with the intent of reconstructing the evolution of the landscape as it is today and shedding insight on paleoenvironmental change and on the impact of dune formation on archaeological sites. This study of geomorphology and soils grew out of a summer 1980 pilot study sponsored by HDR when this firm was in charge of

the archaeological project. D. Johnson, a geographer at the University of Illinois, performed both the pilot and full-scale study, the latter completed during the summer of 1982.

The research design for the MX Vandenberg Archaeological Project was developed concurrently with the bulk of the fieldwork. A preliminary and incomplete draft, prepared by S. Craig under the auspices of HDR, was circulated to the State Office of Historic Preservation and COE in November 1980. Based on comments received, a full draft, also prepared by Craig, was issued by CCP in March 1981. This draft was reviewed by the same parties, with the addition of Advisory Council on Historic Preservation. Because the reviewing parties saw problems with the articulation of certain aspects of the proposed research activities with specific research problems, UCSB's Office of Public Archaeology was subcontracted by CCP in June 1981 to revamp the research design so as to address properly the reviewers' concerns. A final version of the research design prepared by UCSB-OPA was issued in August 1981 (Snethkamp 1981), and a draft "addendum" to the research design, which expanded upon certain of the research problems, was issued November 1981. An "implementation" supplement to the research design, as well as a final version of the "addendum," was issued in January 1982 (Moore 1982).

Although the development of the research design spanned a long period of time, each version took advantage of the increasing amounts of information being generated by the fieldwork. That is, each version represented refinement of research problems and approach made possible by the increasing knowledge of the nature of the archaeological record on the San Antonio Terrace. Furthermore, the successive versions and additions were increasingly focused on how the data analysis was to proceed in light of the fact that the data collection was nearing completion.

Another aspect of the project ongoing through the course of the fieldwork was the development of a program for involving the interests and concerns of local people of Chumash Indian descent with the archaeological investigations. Such a program was required by the Determination of No Adverse Effect document signed by the Air Force at the beginning of the project, and has otherwise been a convention of previous archaeological projects at Vandenberg and in Santa Barbara County in general.

Since a major concern of local Chumash groups has been with the nature of subsurface investigations, especially if prehistoric burials are encountered, efforts were made to involve individuals representing Chumash Indian groups as trainees or monitors whenever excavations took place. In the course of excavations undertaken in 1980 by UCSB-OPA, individuals from the Santa Ynez Indian Reservation located near Solvang were employed as monitors of the excavation activities. This practice continued during the period when HDR was directly responsible for excavations, although some of the monitors came from Chumash groups located in the vicinity of Santa Barbara as well as the reservation. Toward the end of HDR's involvement with the project, the arrangements for monitoring had broken down for reasons that are not clear today, and when CCP took over the project in early 1981, a new monitoring program had to be established.

In light of concerns expressed by the Air Force and COE that a formal arrangement for Native American involvement be established, COE decided that an appropriate first step would be to determine the existence of all Chumash Indian interest groups in the area and to survey their interests and concerns regarding archaeological programs at Vandenberg. CCP ethnographer J. Munoz performed this work and prepared a report covering these subjects (Munoz 1981). This accomplished, a series of meetings was held in February and March 1981 with the Chumash Indian groups, with both CCP and COE representatives in attendance. These meetings led to the drafting of a memorandum of understanding between the Air Force and the Chumash Indian groups, who at this point had organized under an Advisory Council. At the time, however, the Advisory Council was never able to realize the full support of all Chumash groups, and therefore the memorandum of understanding was never signed by all participating parties. Nonetheless, elements of the memorandum of understanding concerning involvement of the Chumash with the MX Vandenberg Archaeological Project were implemented by CCP. Specifically, a field training program in which interested Chumash representatives would participate in the project as paid field crew trainees was developed and implemented in August 1981, and toward the end of the year, when the bulk of laboratory activities had been moved to the CCP office in Santa Barbara, a laboratory trainee was employed.

ORGANIZATION OF THE REPORT

The purpose of the remainder of this report is to present the results of the Vandenberg MX Archaeological Project. In the following chapter the research design governing the activities of the project is presented, along with the changes to it during the course of the project. In Chapter 3, descriptions of the archaeological investigations are presented. Procedures used to collect and process the archaeological data are discussed, and each geographic segment of the investigations, whether in terms of individual sites or construction areas, are described. Chapters 4 through 9 are devoted to the analysis of specific categories of data, and the discussions in Chapter 10 attempt to synthesize these specific analyses into a synthetic picture of the archaeology and prehistory of the San Antonio Terrace. Finally, Chapter 11 presents a conclusion to the report as a series of recommendations for future research on the San Antonio Terrace and for a program to manage San Antonio Terrace cultural resources.

Chapter 2

PROJECT RESEARCH DESIGN

BACKGROUND

The research design for the Vandenberg MX Project underwent a variety of modifications and refinements through the course of the project. At the time fieldwork began, there was no project research design in place to guide the investigations. As discussed in Chapter 1, this predicament was a product of insufficient lead-time prior to the initiation of construction activities, resulting in the early phases of fieldwork being governed by research interests and procedures that had developed as a result of earlier archaeological research on Vandenberg (especially that connected with Space Shuttle development) and more generally in Santa Barbara County. Although research questions guiding the initial phases of fieldwork were never made explicit in a written document, several nonetheless guided the investigations. These may be reconstructed as follows:

1. Were there any archaeological deposits buried under the dune sands such as what was found to exist in 1978 at SBa-670 on south Vandenberg (Glassow et al. 1981:8-12)?

2. How ancient were the sites, and how does the age of each site relate to episodes of dune movement?

3. In light of abundant evidence from sites all over Vandenberg of the manufacture of flaked stone tools, do any of the sites in the MX project area contain evidence of knapping activities, and if so, what kind of tools were made and what stages in tool manufacture are represented?

4. To what extent were a site's inhabitants dependent upon particular classes of resources, including shellfish, marine fish and mammals, large and small terrestrial mammals, waterfowl, marshland plant resources, seeds, and acorns?

5. Based on answers to the above questions, as well as information from other sites in the study area and beyond, what is the place of each site in a subsistence-settlement system?

These questions are, of course, basic to developing an understanding of prehistoric cultural systems that once existed in the Vandenberg region. Because so little information currently exists regarding the nature of prehistoric subsistence and settlement in the Vandenberg region, the questions approach the research on a relatively general level. Nonetheless, the first two questions do take into consideration the relatively unique environmental context of the project area. It was recognized at this early stage that the stabilized dunes in which (and under which) the sites occur make archaeological data collection difficult and provide opportunities for investigating the relationships between environmental change and cultural development.

Data collection procedures used at the outset of the project were oriented toward the problem of delimiting boundaries of sites in a dune environment where shifting sand may have covered up some or all of the surface of a site. The locations of surface finds were mapped with surveying instruments, and shovel test pits (STPs) were excavated along transects radiating out from definable boundaries of sites. Units were excavated to produce information on the vertical characteristics of deposits. Deposits from STPs or units were passed through 1/8 inch or, when sufficiently sandy and dry, through 1/16 inch mesh screens in order to retrieve samples of faunal remains and lithics. Screening at these meshes was necessary because many items were found to be less than one-eighth of an inch (approximately 3 mm) in size. Various systematic sampling designs were used to place STPs or units within the zones of potential impact, although compromises in the rigor of sampling designs had to be made because of the very short periods of time available for investigation prior to construction.

The first research design document was issued in preliminary form in the fall of 1980. By this time, several refinements in research problems had been made. First, the wetlands occupying the swales between ridges in the intermediate dunefield were hypothesized to have been important aboriginal resource areas. Marsh-dwelling plants such as cattail (Typha latifolia) could have been exploited as food resources, and the leaves and stalks of willow (Salix spp.) and wire-grass (Juncus spp.) could have been important materials for house construction and the manufacture of basketry and other items. It was also noted that deer frequent the wetlands and therefore would have been conveniently hunted at such locations. Because of the potential importance of wetlands as resource areas, it was hypothesized that the locations of sites might somehow be related to wetland locations, especially those which appeared to be more stable through time (e.g., the Turtle Pond locality toward the northern end of the project area).

Second, enough had been seen during the surveys and test excavations carried out in the first weeks of the investigations to reveal that waste flakes resulting from flaked stone tool manufacture varied significantly in size composition between sites. Some sites contained only very small flakes, usually less than 10 mm long, whereas others contained much larger flakes as well. It was therefore hypothesized that some sites appeared to be loci where

tools such as chert knives were resharpened or where final stages of manufacture of such tools were carried out, whereas other sites represented loci where a greater variety of activities were carried out. Likewise, it was recognized that faunal remains, particularly shellfish remains, tended to be in greater densities at sites located on the peripheries of the intermediate dunefield, especially along the southern periphery overlooking the San Antonio Creek. These variations led Craig, the author of the first version of the research design, to propose a site typology consisting of nine categories. Although there was no formal analysis to justify the divisions within this typology, it did focus attention on the fact that significant variability between sites does exist.

Third, the available data indicated that many sites were very small, some no more than several meters in diameter and of minimal depth. It appeared, therefore, that sites within the intermediate dunes very likely represented discrete episodes of prehistoric activity, some perhaps taking place within only one day. Discrete concentrations of faunal remains and chert flakes in some of the larger sites appeared to represent similarly short activity episodes. It was proposed, therefore, that a distinct advantage of sites within the dunes was their potential for studying short-term activities, which tended to be blurred in sites outside the dunefields where shifting sand had not separated activity episodes one from another.

The only appreciable change in field procedures specified in the initial version of the research design was the formal adoption of shovel test pits as a supplement to surface survey.

Although the initial version of the research design authored by Craig was never adopted, it did provide guidance to the field activities until the adoption of the UCSB-OPA version in January 1982. The main failing of the initial version, as pointed out by COE, was a lack of clear integration between research problems, data collection and processing procedures, and analytical approaches.

OVERVIEW OF THE ARCHAEOLOGY OF THE NORTHERN VANDENBERG REGION

An archaeological research design must necessarily take into consideration the results of previous research in the region, not only because any research project should build upon the knowledge already gained, but also because any shortcomings of the previous research approaches can be recognized and compensated for. Therefore, an overview of the earlier research in the Vandenberg region is presented here as the first element of the research design. Since an archaeological overview of the Vandenberg region as a whole has recently been written (Glassow et al. 1981), this overview will focus on the archaeological investigations in the northern Vandenberg region.

Ethnographic Background

Very little is known of the aboriginal inhabitants of the Vandenberg region. Limited ethnohistoric and ethnographic information indicates that inhabitants of the region were Indians speaking the Purisimeño language of the Chumash linguistic family, and for this reason they have been referred to as the Purisimeño Chumash (Greenwood 1978; see also Appendix I of this report). The geographic extent of the Purisimeño Chumash has been subject to varying interpretations. Some scholars (Grant 1978:506) do not include any of the Santa Barbara Channel within Purisimeño territory, whereas Greenwood (1978:521) and C. King (1975:174 and Appendix I) include lands from Gaviota on the Santa Barbara Channel westward. Similarly, Grant (1978:506) and apparently Greenwood (1978:520) place the northern boundary in the vicinity of the town of Oceano on the Pacific coast, whereas King (1975:174 and Appendix I) places it farther south in the vicinity of Point Sal. King also extends the boundary farther east than Grant and Greenwood. As King discusses in Appendix I, there is considerable ethnohistoric and ethnographic justification for his boundaries, and they are therefore considered more correct.

Ethnographic information on Chumash culture is most extensive for the Barbareño, Ynezeño, and Ventureño Chumash, who occupied territories east of the Purisimeño. What little is known of Purisimeño Chumash culture is derived principally from the journals of early Spanish expeditions through Purisimeño territory and from ethnographic information, obtained second hand, so to speak, from descendants representing other Chumash groups. King's analysis presented in Appendix I represents an attempt to expand the knowledge of the Purisimeño through the analysis of genealogical data contained in baptismal, marriage, and death registers, as well as other mission records that contain genealogical information.

Like their neighbors to the east, the Purisimeño were hunter-gatherers who exploited a variety of marine and terrestrial resources. However, as reflected in the subsistence remains in archaeological sites, marine fishing was not as important among those Purisimeño populations living north of the Santa Barbara Channel, while shellfish collecting appears to have been more important (Glassow and Wilcoxon 1979). The reduced emphasis on marine fishing is consistent with the aboriginal absence of the Chumash plank canoe north of Point Conception (Greenwood 1978:521-522). Acorns may have been as important a staple among the Purisimeño as it was among most other Chumash groups, although the Purisimeño would have had to travel several kilometers inland from the coast to find sufficient numbers of oaks, or trade with inland groups for this resource. Greenwood (1978:522-523) notes that Purisimeño technology and items of their materials culture were quite similar to that of the Chumash to the east.

While Purisimeño villages located on the Santa Barbara Channel tended to be relatively large--containing between about 100 and 300 individuals apiece--those north of Point Conception were generally smaller, many containing considerably less than 100 individuals. Concomitantly, population

density north of Point Conception was lower. Furthermore, those Purisimeño villages located on the coast north of Point Conception were on the lee (south) side of prominent points of land, and the majority of villages were located inland. This avoidance of all but quite protected locations on the coast is undoubtedly a product of the exposure of the coastline north of Point Conception to strong prevailing winds and heavy winter surf. South of Point Conception, the coastline is more protected, allowing for the coastal location of villages.

In Appendix I, C. King identifies four and possibly five Purisimeno villages that were located in the immediate vicinity of the study area. These are the villages of Atajes, Lospe, Saxpil, Estep, and Nucsuni. The last is only very tentatively located near the study area, and Saxpil may actually fall within the northeast corner of the study area. None of the sites has been firmly correlated with archaeological sites, although, as King points out, Lospe is very likely at SBa-512. King postulates that a linguistic and social boundary falls somewhere just beyond the northern edge of the study area. Indeed, the boundary between the Purisimeño and their Opispeno neighbors to the north may be roughly correlated with the Casmalia Hills. This boundary is especially significant because it separates two major divisions of the Chumash linguistic family. The Purisimeño language is joined with those languages spoken by Chumash to the east to form a group that ethnographically has been referred to as Lulapin. Obispeno, spoken by Chumash north of the Purisima Hills, was apparently noticeably distinct from the languages in the Lulapin group (see Appendix I and Shipley 1978:90).

Significantly, King cites Spanish observations made during the 1769 Portolá expedition indicating that an apparent seasonal camp existed in the study area near MOD Lake or perhaps near the lagoon at the mouth of San Antonio Creek. The inference of seasonal occupation is based on the absence of houses. King surmises that the people seen by the Portolá expedition at this camp came from the base village of Saxpil, which was apparently located inland. If this reconstruction is correct, it implies that the Purisimeño of the study area occupied camps near the coast and the lower San Antonio Creek during the summer (the camp at MOD Lake was occupied during August 1769) but not during the winter and spring (the camp was not occupied in January or May 1770 or March and April 1776 [Landberg 1965:139]). This is the most specific information recorded in the ethnohistorical documents pertaining to settlement patterns in the study area.

Past Archaeological Research In And Around The Study Area

The Vandenberg MX Archaeological Project is connected with the second of two major Federal development programs requiring archaeological investigations on Vandenberg. The earlier archaeological project, in response to the construction of Space Transportation System (Space Shuttle) facilities on south Vandenberg, was separated into two major phases, the first consisting of an intensive survey supplemented by limited subsurface testing in prospective zones of construction impacts (Spanne and Glassow 1974;

Glassow et al. 1976), and the second consisting of excavations at four sites to be impacted by road widening (Glassow et al. 1981; Rudolph 1983). The preliminary report on the 1978-1980 investigations connected with the latter phase (Glassow et al. 1981) contains an overview of previous archaeological investigations throughout the entire Vandenberg region, and to minimize redundancy, attention will be focused here on investigations within or very close to the San Antonio Terrace study area.

The first documented archaeological excavations within or near the study area were undertaken in 1874 by Paul Schumacher from the Smithsonian Institution (Schumacher 1875). Over a three-month period, Schumacher visited a number of sites on or near the coast between Port San Luis and Point Sal, carrying out excavations at several that looked promising. He describes a large shell midden site on the lee side of Point Sal, but he apparently did not excavate there. After unsuccessful investigations at a site near the mouth of the Santa Maria River (SBa-1209), he located a site in the Casmalia Hills within a few kilometers of Point Sal at which he excavated about 150 graves (apparently SBa-1094). He was told by "old Spanish residents" that the site was called "Kesmali." King proposes in Appendix I that Kesmali (from which the town of Casmalia takes its name) may be another name for the Purisimeño village of Saxpil. It is unlikely, however, that this particular site was either Saxpil or some other protohistoric/historic Purisimeño village, because Schumacher does not report finding any historic artifacts (such as glass beads), nor does his description of the graves fit closely that of a cemetery of late prehistoric age.

Schumacher returned to the area in early 1876 (Schumacher 1877), beginning his investigations at the site in the northwestern extreme of the study area that he had located in 1874. Old Spaniards told him that this site was called "Osbi," which is clearly derived from the Chumash village name of Lospe (see Appendix I). His description of the site fits best that of SBa-512. Schumacher excavated nearly 400 burials, but he does not report encountering artifacts of historic age, so the attribution of this site to the Purisimeño placename of Lospe is still questionable. Schumacher moved on to a site located just east of a residence occupied by "the stock-raiser Olivera" (see Appendix II for details pertaining to the Olivera family). He had poor luck at this site because of prior looting. Earlier in the MX project research, the site designated SBa-1174 was suspected to have been the location of Schumacher's visit. However, Schumacher's map of the locality (1877:Plate 20) best fits a location about one kilometer southeast of SBa-1174 where archaeological survey has not yet been accomplished.

Schumacher's investigations came at a time when American archaeology was in its first stages of becoming a professional discipline. During this time, the basic objective of archaeology was to discover and describe antiquities of regions of the United States for which no knowledge of prehistory yet existed. Further, museums such as the National Museum of the Smithsonian Institution were interested in obtaining artifacts representative of regions such as southern California that could be placed in

public exhibits. As a result, Schumacher and his archaeological colleagues focused their excavations on those portions of sites that predictably would yield the highest return in complete artifacts for the amount of labor invested, and recovery concentrated on those artifacts that exhibited qualities distinctive of particular regions or exhibited a high degree of craftsmanship. The cemetery areas of sites were therefore sought because southern California cemeteries typically contained mortuary offerings of the kinds of artifacts of most interest. Since artifacts needed only to be representative of a region, few data were collected concerning the provenience of artifacts within sites, and, in the case of Schumacher, he often did not even record the specific site from which objects came.

Schumacher's collections are now housed in the Smithsonian Institution in Washington, D.C. However, no research has been undertaken to determine their current status. If the collections are still largely intact at the Smithsonian, and if Schumacher recorded particular sites from which they came (which appears not to be the case), these collections have considerable research value. Typically, cemetery collections contain artifacts with forms distinctive of particular periods of prehistory, and it should be possible to assign approximate dates to the cemeteries in which he excavated. The collections could also be helpful in studies of trade and exchange (some artifacts were likely made by peoples living on the Santa Barbara Channel) and comparative social organization (Schumacher mentions that some burials contained many more artifacts reflecting high social status than others in a given cemetery).

Following on the heels of Schumacher was the amateur archaeologist Stephen Bowers, who visited the Vandenberg region in 1877. His investigations might best be described as a reconnaissance, because his journal indicates that he spent no more than four days travelling through the region (Benson 1982). He mentions visiting sites near Point Sal and then moving north to a site near Guadalupe. This site has been tentatively identified as SBa-515, overlooking the southern margin of the Santa Maria Valley (Glassow et al. 1981:2-6). Bowers' field journal indicates that he did little or no excavation, but he nonetheless did make substantial collections, apparently from the surfaces of sites where wind deflation had exposed many artifacts. The bulk of these collections are currently housed by the Smithsonian Institution.

In 1900, Philip Mills Jones, an amateur archaeologist connected with the University of California at Berkeley, carried out cursory investigations in the vicinity of Guadalupe. In his journal (Jones 1900), he mentions making an extensive collection from presumably the same site visited by Bowers a few years earlier; most of the collection was apparently from the wind-deflated surface of this site. Jones reports numerous manos and metates (the latter mistakenly identified by him as mortars) scattered on the site surface, which may indicate that this site is between 7,000 and 9,000 years old, if radiocarbon dated assemblages of this sort from south Vandenberg are any indication (Glassow et al. 1976, Martz 1976; Glassow et al. 1981). Jones also

mentions visiting sites in the vicinity of Point Sal, where he saw evidence of earlier excavations attributed to Schumacher and Bowers. Jones' collections are currently housed in the Lowie Museum at the University of California, Berkeley.

Jones' and Bowers' investigations were relatively casual, and their contributions to understanding the prehistory of the region are relatively minimal. Their journals, the only written documentation of their research, do not provide much useful information. Their collections may have some research value, but this has not been assessed.

There is no indication of archaeological investigations in the vicinity of the study area over the next 30 years. Beginning in the 1930s, however, Clarence Ruth, a resident of Lompoc and an amateur archaeologist with apparently some professional training at the University of Southern California, began wide-ranging investigations in the Vandenberg region. His investigations are reported in three unpublished manuscripts (1936, 1937, 1967). Ruth is responsible for the first effort to inventory sites in the Vandenberg region, which he plotted on a small-scale map and to which he assigned consecutive numbers (Ruth 1936, 1967). Eight of the sites he recorded and briefly described are located within or very near the study area (Numbers 42 through 49).

He appears to have undertaken excavations at only one of these sites, which he referred to as the Casmalia Site (not to be confused with Schumacher's Kasmali) and assigned the number 45 in his 1967 report. His description and map of the site indicates that it includes the northern end of Schumacher's "Osbi," or SBa-512, as well as SBa-513 and -941. Ruth's excavations, undertaken in 1935, appear to have been limited to the latter two sites, where he discovered a "main burial plot" in SBa-513 and "smaller plots" in SBa-941. Beads and ornaments associated with the burials are of styles prevalent between about A.D. 300 and 900, according to King's chronology of shell and bead types (his phases M3 and M4 [C. King 1981]).

J. B. Lillard of Sacramento Junior College (now Sacramento State University), in the company of students and colleagues, also carried out excavations at this site over a 45-day period in 1935, and Ruth includes in his 1967 report a transcription of Lillard's cursory field notes for those excavations that were expansions of his. However, Lillard's original field journal indicates that he carried out other excavations elsewhere in the site complex (Lillard 1937). Ruth and Lillard together seemed to have encountered only about ten burials. Ruth's collections are now housed by the Lompoc Valley Historical Society in their museum in Lompoc, and Lillard's collections are presumably at either Sacramento State University or the Lowie Museum of the University of California, Berkeley.

While Ruth's and Lillard's excavation focused to some extent on cemeteries, when these could be found, they also excavated in other parts of the site, generally using trenches. They were also concerned with keeping at least rudimentary field notes of their excavations, and at least portions of

their collections are provenienced to particular sites. In these regards, their data recovery techniques were more rigorous than those of their predecessors. In addition, Ruth attempted to relate his data to the chronological sequence developed for the Santa Barbara Channel by D. B. Rogers (1929), thus providing the first insight into the probable antiquity of Vandenberg region sites and the first indications that many of the artifact forms from the Vandenberg region were quite similar to those of the Santa Barbara Channel.

In 1950 and 1951, Ruth's site locational information came into the hands of archaeologists from the UC Berkeley Archaeological Survey, who were carrying out excavations and reconnaissances in Santa Barbara County. The Archaeological Survey staff assigned SBa- numbers to Ruth's sites at that time and included them in the master file for the State of California. SBa-numbers in the 200s represent sites originally recorded by Ruth (some have since been renumbered).

G. F. Carter (1943) carried out the first stratigraphic excavations near the study area in the late 1930s at SBa-125, a site 4 km inland from Point Sal in the Casmalia Hills. Within the maximum depth of 10 feet (3 m) of deposits at this site, Carter was able to discern three distinct strata. The lowermost, designated Stratum I, yielded a number of metates and manos and heavy notched projectile points. Stratum II, consisting of a soil with more ash and shell than Stratum I, yielded mortars and pestles as well as metates and manos, and projectile points were typically of the contracting stemmed type. Stratum III, the uppermost, contained mortars and pestles (but no manos and metates) and small projectile points deemed to be for arrows.

Carter related the sequence of artifact types represented in the stratigraphy of this site to the Santa Barbara Channel chronological sequences developed by Rogers (1929) and by Olson (1930). He argued that Stratum I correlated with the earlier part of Rogers' Hunting Period and Olson's Early Mainland Period, Stratum II correlated with the later part of Rogers' Hunting Period and Olson's Intermediate Mainland Period, and Stratum III correlated with Rogers' Canalino Period and Olson's Late Mainland Period. These chronological assignments may be essentially correct, but there is the possibility that Stratum I may represent an occupation earlier than Carter thought, within what Rogers called the Oak Grove Period. The side-notched projectile points may be similar to those obtained from SBa-53, a Hunting Period Site on the Santa Barbara Channel dated at ca. 5000 years ago (Harrison and Harrison 1966). SBa-53 contained mortars and pestles along with metates and manos, however, a trait more consistent with Carter's Stratum II assemblage. Moreover, side-notched projectile points occur in earlier Santa Barbara Channel sites as well, such as site SBa-142c, which has been radiocarbon dated between 6,300 and 7,200 years ago (Owen, Curtis, and Miller 1964). On south Vandenberg, heavy corner-notched points, which may be typologically comparable to Carter's side-notched points, occur at SBa-931, which is radiocarbon dated between 7,900 and 8,900 years ago (Glassow et al. 1981). This site also contained exclusively metates and

manos. In conclusion, there is at least as much justification for correlating Carter's Stratum I with the first of Rogers' periods as there is with the early part of the second. Unfortunately, Carter's published report is too cursory for a more detailed evaluation, which would require reference to the collections from this site, presumably housed in the San Diego Museum of Man.

In the late 1950s, another site just north of the study area in the Casmalia Hills was the subject of archaeological excavations. The construction of military facilities on the base endangered SBa-734, but before destruction, Laurence Spanne, a teenager growing up in Lompoc at the time, salvaged approximately 50 burials from this site with the help of relatives and friends (Ruth 1967:82; Spanne 1970:3, 6). Mortuary offerings from this site included a variety of shell, stone, and bone beads, ornaments, and artifacts of types and abundances comparable to those discovered in coeval cemeteries in sites along the Santa Barbara Channel. C. King (1981:61) has placed this cemetery in Phase M4 (A.D. 700-900) of his chronological sequence. The collection is still in the hands of the Spanne family.

Spanne's interests in the archaeology of the Vandenberg region extended into his adult life, and as a graduate student at UCSB, he began systematic archaeological surveys on the base. In the summer of 1969, these surveys were in connection with a UCSB archaeological field school and covered lands on the Sudden Ranch tract at the southern extreme of the base (Benson 1969) and from Shuman Canyon north toward Point Sal (Spanne 1970). These surveys were continued in 1970 under a contract between UCSB and the National Park Service, with funds to offset some of the costs of the survey provided by the Air Force. During 1970-1971, Spanne and his field crew surveyed primarily along the coastline of the base and recorded 208 sites, of which 30 had been cursorily recorded previously. The contract was extended in 1971, and intermittently between 1971 and 1973 Spanne (1971, 1974) extended his intensive surveys to cover eventually about 70 percent of the base's area. In addition, he had performed "controlled intuitive" survey over an additional 20 percent of the base. While his systematic survey involved walking over the ground in transects spaced 30 to 60 m apart, controlled intuitive survey involved checking localities that past experience indicated had a high chance of containing archaeological sites. By the end of his surveys in 1973, the number of recorded sites had jumped from about 30 to 421, thus representing one of the highest recorded site densities in the state.

In most respects, Spanne's surveys are of high quality by modern standards. In particular, the accuracy of his plotting of site locations on maps is quite high, and the majority of the State of California site record forms are carefully filled out, often with more information than elicited by the form. The ground coverage of his systematic survey has since proven not to be as thorough as is now generally required, largely because of the considerable breadth between walking transects and the inexperience of some members of his volunteer survey crews. A resurvey of lands near the coast on south Vandenberg in connection with Space Transportation System planning

(which Spanne supervised) doubled the number of sites previously located (Spanne and Glassow 1974). Furthermore, Spanne had recorded only several sites in the intermediate dunefield of the study area, but surveys in the project area revealed a high site density. Generally speaking, Spanne's 1969 to 1973 surveys tended to miss relatively small sites containing low-density surface scatters of archaeological items.

Despite these shortcomings, Spanne's survey did provide a detailed picture of the nature and distribution of archaeological sites on the base. Not only was the site density shown to be impressively high, but some interesting patterns in the distributions of sites of differing types could be discerned. The highest concentrations of sites occurred along the coast and the edges of major steams. Because these sites also tended to contain the densest midden debris, many fit into Spanne's site types designated "sedentary or semisedentary villages" and "seasonal villages or intermittently occupied habitation sites." Spanne also noted that coastal sites falling into these two categories tended to be on the bights of prominent points of land (i.e., Point Sal, Purisima Point, Point Arguello) where more protection from the prevailing winds could be obtained. His other four site types are "temporary sites," "ideological sites" (i.e., rock art sites), "historic Spanish or Mexican Period sites," and "historic Anglo sites." Unfortunately, funding was not available either to complete the survey of the base or to undertake an intensive analysis of the survey data so that Spanne's site types could be more objectively defined.

In the course of survey during 1972, Spanne discovered a site, SBa-1010, located on the edge of Barka Slough, a marshland along the San Antonio Creek about 13 km inland from the coast. The site is buried under about 3 m of alluvial fan deposits, but is exposed along a bank caused by stream erosion. Spanne noted that the site contained an unusally large amount of animal bone, as well as stone tools, and he deemed the site worthy of salvage excavation. Cutting back a portion of the bank, he exposed two thin occupational layers in which the preservation of bone and charcoal was excellent. Much of the bone, as well as large pieces of antler, was identified as elk, and some pieces had been worked into tools (Spanne 1973). No other Vandenberg site has yielded elk bone or antler, although fragments of cervid bone large enough to be elk have occasionally been seen on the surface of Vandenberg sites. That elk may have been present aboriginally is likely in light of the extensiveness of the Barka Slough, which would have provided an ideal habitat for these animals. A radiocarbon date from this site indicates an age of 2,200 years ago (Glassow et al. 1981; Appendix 2). Spanne prepared a report containing a basic description of his investigations and the collections. An intensive analysis of the data from this site would certainly be a worthy endeavor.

None of the above archaeological projects has involved intensive analysis of data. However, M. E. Roberts' (1975) analysis of flaked stone tools departs from this pattern. Using surface collections obtained from SBa-1209, the site in the Santa Maria Valley investigated by Schumacher in 1874, and

from a site at Purisima Point (probably SBa-225), Roberts attempted to demonstrate the potential of the analysis of microwear on the edges of stone tools flaked from nodules of Monterey chert (mistakenly identified as Franciscan chert by Roberts). The forty-three tools from SBa-1209 and eighty from the Purisima Point site subjected to microscopic examination under 60x were argued to exhibit evidence of cutting or scraping of hard or soft materials. Since the two sites exhibited differing proportions of edge types, Roberts argued that the sites represented functionally different camps.

There are a number of problems with Roberts' analysis. First, there is no indication as to how the collections were made. Differences in collection techniques could, of course, seriously affect tool samples and therefore the analysis. Second, the morphological aspect of the tools, as well as their propensity for edge damage, could be affected by differences between the sites in the quality of Monterey chert. Third, as pointed out by Bamforth in Chapter 9, a variety of other processes in addition to tool use can cause edge damage, and the types of edge damage visible under 60x that are the result of tool use do not have a close relationship to particular uses. Therefore, although Roberts' analysis does demonstrate that flaked stone tools are sufficiently abundant at some sites in the Vandenberg region for functional analysis and that edge damage, whatever its causes, is present, he did not necessarily identify the types of use-caused edge damage that actually occur on the tools.

Mention should be made of another analysis of flaked stone tools from Vandenberg sites, this being Spanne's (1975a) consideration of the function of a particular class of crude bifacial tools which have generally been called preforms. Actually, Spanne was not so much concerned with the analysis of these tools as he was with proposing hypotheses to account for their abundance at many Vandenberg sites and various means of testing the hypotheses through further research. Since preforms are abundant in collections obtained on south Vandenberg as a consequence of Space Transportation System construction, the testing of Spanne's hypotheses is a major focus of the ongoing analysis of those collections.

With the passage of the National Environmental Policy Act of 1969 and particularly the Archaeological Conservation Act of 1974, archaeological investigations were required of most land-modifying developments on Vandenberg. Besides the development of MX test facilities, a number of much smaller projects have transpired. Two of the smallest were surveys by Spanne of a cable trench between Minuteman launch facilities 21 and 23 in the Casmalia Hills, north of Shuman Canyon (Spanne 1975c), and of Casmalia water system improvements near the town of Casmalia (Spanne 1982). Although sites were previously recorded in the vicinity of the former project, no new sites were found during either of Spanne's surveys. Spanne (1981a, 1981b, 1981c) also conducted a succession of three small surveys near SBa-593, a site just beyond the eastern edge of the intermediate dunes, in connection with proposed improvements to Jesus Maria Oilfield facilities. These surveys failed to yield evidence of aboriginal activity, although an

apparently recent buried charcoal lens was encountered. Larger scale surveys were performed by UCSB-OPA of security clear zones around a variety of facilities located throughout the base (Stone and Haley 1981). Two of these, located around the Titan Ground Guidance Station and the VTS facility, are located just east of San Antonio Terrace. Two previously recorded sites were noted to be partly within the security clear zone around the VTS facility, but no data were collected from them.

In 1981 and 1982, wide-ranging survey was performed by WESTEC Services for Union Oil Co. of California in connection with their seismic testing for oil exploration along transects crossing the San Antonio Terrace and Burton Mesa (WESTEC 1981, 1982). These tests required clearing vegetation and coring at specific spots along the transects, and WESTEC archaeologists first surveyed the transects and then monitored the vegetation clearing and coring. Of the 34 sites encountered during survey and monitoring, 14 had not been previously recorded. Seventeen isolated artifacts were also located, two of which were projectile points and were collected. This survey is especially relevant to the Vandenberg MX Archaeological Project in that it revealed that a number of unrecorded sites still exist on the San Antonio Terrace outside the MX test facilities project area.

Another survey involving lands in the study area was undertaken by USCB-OPA in 1981. This survey was of corridors proposed as fuel breaks and fire breaks, as well as small tracts of land on which controlled burns were proposed (Neff 1982). Several of the fuel break corridors were located north of the study area toward Point Sal, while other corridors as well as burn parcels passed through the center of the study area along El Rancho Road. Three previously recorded sites north of the study area were tested with one to three STPs each, and three stone pestles and a chert preform were collected from the surface of one of these sites. Since National Register assessments had already been made of the nine previously recorded sites encountered on the San Antonio Terrace, no subsurface testing was necessary. One new site, just beyond the boundaries of a fuel break corridor, was located in the extreme northeastern corner of the study area, about .5 km south of Casmalia.

Unlike the reports of the other surveys just mentioned, the fuels management report by Neff included an analysis of aspects of the data collected, particularly flaked stone objects. Although the data were too few for a meaningful quantitative analysis, Neff recognized that two site clusters, one encountered north of the study area near Point Sal and the other within the study area and overlooking the San Antonio Valley in the vicinity of El Rancho Road, differ in their environmental contexts. The site cluster near Point Sal is relatively near rocky intertidal zones rich in rock-perching shellfish. The San Antonio Terrace site cluster, on the other hand, is within a habitat where deer and other terrestrial game abound and marshlands are nearby. Neff noted that shellfish collection was clearly more important to the occupants of the Point Sal site cluster, as reflected in the high densities of

shellfish remains in the sites, whereas hunting was possibly more important to the occupants of the San Antonio Terrace site cluster, an inference supported by the nearby isolated find of a projectile point.

Neff also noted that the sites in the San Antonio Terrace site cluster tend to contain chert waste flakes representing only the final stages of flaked stone tool manufacture, whereas two of the sites near Point Sal contain waste flakes representing all stages of tool manufacture. Sites investigated elsewhere on Vandenberg were noted to contain waste flakes representing only the initial stages of manufacturing. Neff (1982:80) argued that two stone tool manufacturing industries are reflected in this patterning. In one, the initial and final stages of manufacture are segregated between sites, while in the other all stages of manufacture take place. Neff did not have sufficient data to determine whether these two industries, and the subsistence foci that correlate with them, are separated in time or are perhaps only seasonal emphases of one subsistence-settlement system, but he proposes that addressing this question would be an avenue of future research.

In summary, archaeological investigations in and near the study area have been sporadic and usually limited in scope. Most excavations have been concentrated on sites near Point Sal and the adjoining western Casmalia Hills, and reports of these have all been cursory. None of the investigations has focused on the San Antonio Terrace as a whole; even Spanne's 1969-1973 survey appears not to have penetrated all areas of the terrace. Regarding the antiquity of prehistoric occupation, Carter's excavations at SBa-125 give some indication of a long prehistory, perhaps spanning the whole 8500-plus years recently documented on south Vandenberg. The prehistoric cemeteries excavated by Ruth and Spanne indicate substantial occupation during the period between about A.D. 300 and 900, and the Barka Slough site, SBa-1010, yielded evidence of even earlier occupation, apparently associated with a fauna that no longer exists in the Vandenberg region. Finally, the several recent surveys performed in and near the study area for the purpose of assessing impacts of land development have added some information regarding the distribution of archaeological sites and their gross characteristics, but the data collected are simply too meager for making significant contributions to knowledge. As more such surveys are done, however, data will eventually accumulate to a point where useful analyses are possible. At the very least, the data collected from these surveys, as well as all those derived from earlier projects, give witness to a rich and varied prehistory of the northern portion of the Vandenberg region.

There is still no established prehistoric chronology for the study area. Carter's sequence for SBa-125 is the closest approximation of such a chronology but it is really too gross to be of much use. Previous investigations, including those of Carter and Ruth, have recognized the apparent relationship between chronologically sensitive artifact types of the Vandenberg region and those of the Santa Barbara Channel, and on this basis they have applied the chronological scheme developed by Rogers (1929) to archaeological sites of the Vandenberg region. The recent investigations on

south Vandenberg in connection with Space Shuttle construction have also used a Santa Barbara Channel chronological scheme (Glassow et al. 1981), but instead of Rogers', a more refined chronology recently developed by C. King (1981) was adopted. This scheme will also be used in this report (see Chapter 7).

NATURE OF THE DATA COLLECTED FROM THE PROJECT AREA

In addition to building upon the previous regional research, a project research design must take into account the nature and abundance of the data expectable from the investigations. This dictum is especially true for archaeological projects involving assessment of cultural resources and the mitigation of impacts to them. In this type of project, many aspects of the data are determined by the manner in which the investigations articulate with a land development project. With regard to the Vandenberg MX Archaeological Project, the land areas surveyed, the sites subjected to subsurface investigation, and the areas within sites investigated were all dictated by the locations of MX test facilities and other areas affected by construction activities. Furthermore, the intensity of the subsurface excavations was determined primarily by whether the boundaries and general nature of the site had only to be ascertained or whether construction impacts had to be mitigated. Even the nature of the construction affected the investigations. Sites impacted by the construction of buildings required excavations within two-dimensional areas, whereas sites affected by road widening and burial of communications lines required excavations along single lines through some portion of the sites. In light of this variety of constraints on data collection, it is appropriate at this point to summarize the nature of the data available for analysis.

Intensive surface survey, often supplemented with the excavation of shovel test pits, was a major project activity (Figure 2-1). Altogether, the survey covered nearly 6 km^2 of land composed of a series of irregularly shaped blocks, some of which are connected by short linear survey areas along road rights-of-way. In addition, about 24 linear kilometers of communications and power line corridors were surveyed. The survey resulted in the location of 13 new archaeological sites and the updating of site records for 25 previously located sites. About two-thirds of the block survey was located in the intermediate dunes comprising the central portion of the San Antonio Terrace, and the other third consisted of contiguous lands on the old dune surface immediately to the southeast. Communications line corridors extended from the block surveyed area southward onto Burton Mesa, and a disjunct power line corridor crossed old dune surfaces roughly 3 to 4 km east of the block surveyed area.

Of the 38 sites located or relocated during the survey, 24 sites were subjected to some form of subsurface testing, and of these, 10 sites were tested only with STPs. Of the other 14 sites subjected to unit excavation, up to two cubic meters were obtained from 8 sites and more than two cubic

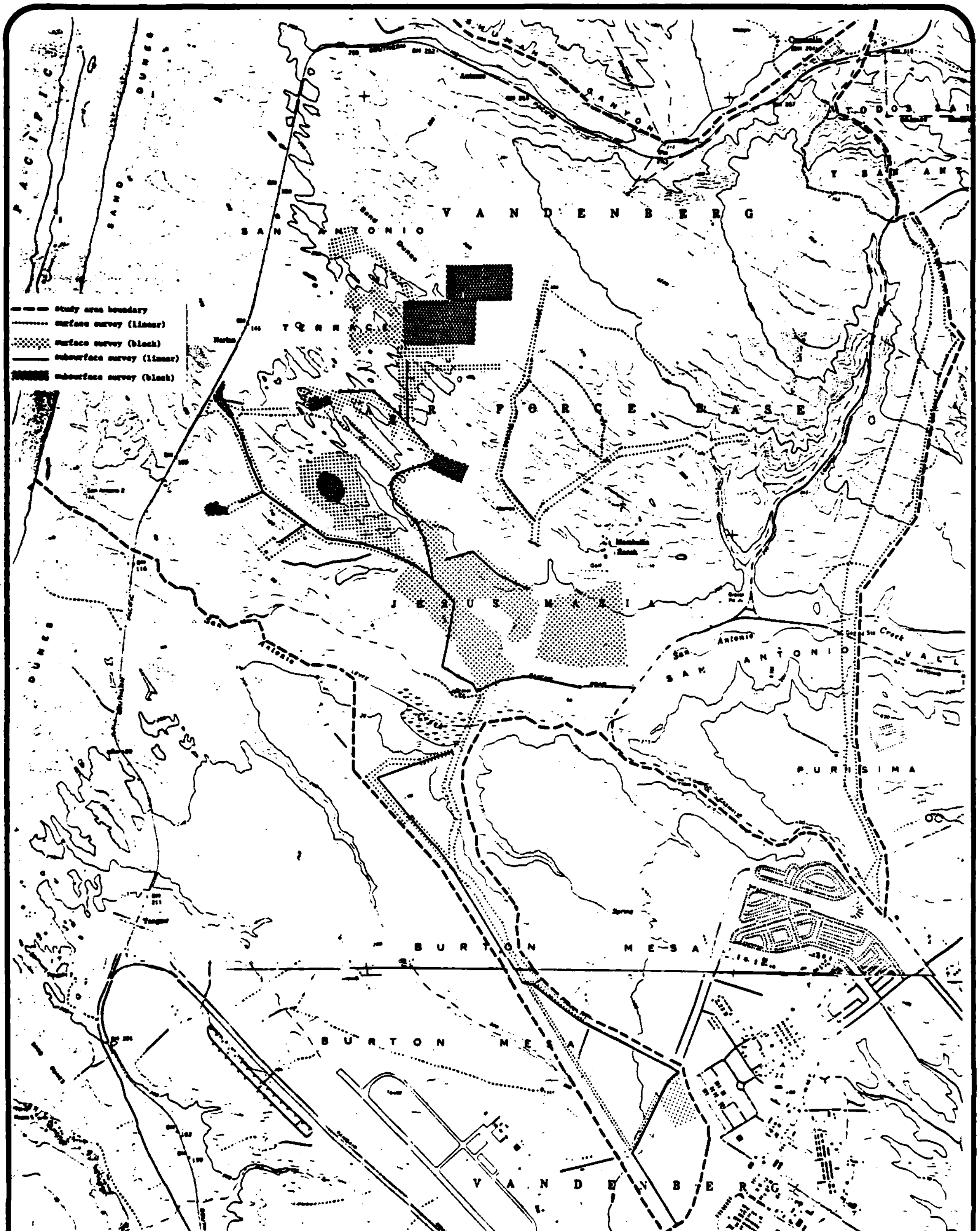

Figure 2-1. Survey Lines and Areas, MX Archaeological Project.

meters were obtained from the others. The total volume excavated during the course of the project is, therefore, quite small, and a large proportion of this total volume, probably more than half, was in the form of STPs.

Aside from the shellfish remains, chert flakes are the most abundant class of items encountered. Of the 19,250 flakes collected, 14,897 are smaller than 1/4 inch (6.4 mm) in length, and of the remainder, only 615 are larger than 1/2 inch (12.7 mm) in length and would therefore be large enough to serve as flake tools. Faunal remains are represented by the bones of a variety of terrestrial mammals, sea mammals, bird, fish and reptile, and by shell fragments representing over 30 species of shellfish. Bone remains, most of which are very fragmentary and come from terrestrial mammals the size of jackrabbits or smaller, total 3,479 fragments weighing 2,009.6 g. Forty-two percent of the bone count came from SBa-706, and 88 percent by weight came from the historic component of SBa-1174. Shellfish remains totalled 9,471.4 g, 14 percent of which came from SBa-706 and 71 percent of which came from SBa-1179.

Actual tools, many of which are fragmentary, are present in very low numbers. Again, the most abundant class of prehistoric tools consists of chipped stone items, including 32 projectile points, 36 preforms and large bifaces, and 92 flake and core tools. Ground stone objects number only three. Two shell beads and two shell tools are also present. Worked bone is absent. A relatively abundant class of artifacts, fire-altered rocks, number 141 items, mainly fragments.

Excluding those sites along communications and power lines, the sites investigated are grouped within a relatively small area of the San Antonio Terrace. This area extends from the San Antonio Creek bottomlands on the south to the center of the intermediate dunefield. While sites are quite dense within the surveyed area, they are relatively rare beyond, giving the impression that the sample of known sites outside the surveyed area is not comparable to that within. Sites along the edge of the San Antonio Creek bottomlands are frequently large, with maximum dimensions of 300 m or more, and the zones between them frequently contain low but noticeable densities of cultural items. In the central portion of the intermediate dunes, sites tend to be small, less than 100 m in diameter, and there are fewer cultural items scattered between them.

The surveys along the communications and power lines beyond the area of block surveys encountered few sites, in part because of the narrowness of the corridor, but also because site densities are probably lower in those areas crossed by the corridors. If the latter is the principal reason, site densities are apparently lower east and south of the area of block surveys.

Something may also be said about the nature of the intrasite samples. In only two instances (SBa-1179 and -1718) were subsurface investigations distributed over essentially the whole site area, and only at SBa-1179 was the complete area tested with units instead of STPs. In the other sites in which units were excavated, these were either concentrated in portions of the site with highest densities of surface indications or were distributed in patterns

dictated by the nature of potential construction impacts. As a consequence, little can be said about the internal structure of most sites. It is noteworthy that SBa-1179 appears to be structurally much more complex than the other sites, but this impression is largely the result of greater volume of unit excavation at this site. SBa-1179 is undoubtedly not as unique as it seems.

THE PROJECT RESEARCH DESIGN

Introduction

The principal theme running through the development of the project research design is that the data collected would be relevant to studies of hunter-gatherer subsistence and settlement. There are good reasons for this. First, it is known through ethnohistory and ethnography that the Vandenberg region was occupied by hunter-gatherers at the time of European contact, and prior archaeological research in the region indicates that this subsistence orientation extends back into prehistory several thousand years. Second, it is recognized that the kinds of data that could be expected to be obtained would be most appropriate to studies of subsistence and settlement in that they were either the remains of subsistence activities, the tools used in obtaining or processing subsistence products, or the residues from the manufacture of such tools. Third, the explication of subsistence-settlement systems may be seen as a prerequesite to studies of other aspects of cultural systems, many of which are closely related to, or even dependent upon, subsistence or settlement. Finally, because the development of theory concerning the subsistence and settlement of hunter-gatherers has been the subject of considerable attention by archaeologists in recent years, it was proposed that the project could take advantage of the existence of this theory and might even be able to contribute to its development.

The study of aboriginal subsistence and settlement of the Vandenberg region has the potential of making several important contributions to the development of cultural anthropological theory. Most fundamentally, knowledge of the nature of Vandenberg region cultural systems provides a body of comparative information so important to theoretical studies of cultural variability. As is the case with cultural developments in any other region of the world, that of the Vandenberg region will eventually be found to have certain uniquenesses that theory must be made to account for if it is to be truly general.

On a more specific level, knowledge of Vandenberg region subsistence and settlement has bearing on an important research problem regarding the significance of marine resources to prehistoric hunter-gatherers who lived in the world's coastal environments. Osborn (1977:172-173) has argued that marine food resources such as shellfish, fish, and sea mammals generally were less favored than terrestrial food resources--in particular, game animals--largely because the return per unit effort expended in acquiring marine foods is lower than is generally the case with terrestrial foods. However, some have questioned this argument (Yesner 1980:733, 745),

pointing out that the costs of obtaining certain marine foods may actually be quite low because of minimal investment in food-getting technology. Because prehistoric subsistence of the Vandenberg region clearly involved exploitation of both marine and terrestrial food resources, the interplay between these two resource bases may be studied with the objective of addressing the subject of this controversy. Comparing prehistoric subsistence in the Vandenberg region with that of the Santa Barbara Channel offers an especially useful body of data in this regard, since patterns of marine and terrestrial resource exploitation in these two regions appear to have differed throughout prehistory (Glassow and Wilcoxon 1979).

Vandenberg region archaeological resources also appear to have bearing on the question of what determines sedentism among human populations. Sedentary village life, or at least relatively low levels of mobility in the course of an annual round of subsistence activities, is relatively common prehistorically in coastal environments, as it is also among those prehistoric groups who depend upon agriculture. A number of factors may be responsible for decreasing mobility and promoting sedentism, including population growth, which may result in reduction of the size of the territory under the control of a local group, or shifts in subsistence focus to resources available from comparatively small locales (T. King 1974:39-40). Again, the Vandenberg region archaeological resources take on added value when considered with those of the Santa Barbara Channel, where aboriginal settlement appears to have been relatively less mobile.

The origins of social complexity is another research topic to which the Vandenberg region archaeological resources are relevant. Although this topic lies beyond consideration of subsistence and settlement, it is closely related to these subjects. At the time of European contact, the Chumash were known to have had a sociopolitical organization characterized by ranked status positions and hereditary political offices (L. King 1969; C. King 1981), a pattern reported for a number of other groups in California (Bean 1974, 1978). Sociopolitical complexity among nonliterate societies of the world appears to have arisen in the context of two different subsistence-settlement contexts: agriculturalists living in permanent villages and hunter-gatherers subsisting on highly productive wild food resources and living in relatively large base camps for the greater part of the year. Social ranking, according to Fried (1967:113, 117, 183), is associated with redistribution of resources, an economic arrangement arising in the context of population growth.

The available data from excavated cemeteries in the Vandenberg region provide some evidence of social ranking prehistorically, and C. King argues in Appendix I that ethnohistoric data may be interpreted as indicating social ranking existing among the Purisimeno Chumash. Assuming that ranking did exist protohistorically in the Vandenberg region, one may ask how it was related to the economy and under what conditions did it arise prehistorically. Such questions gain special interest because of the relatively low density and relatively high mobility of aboriginal population in the Vandenberg region. In other words, the prehistory of the Vandenberg region provides an example of the rise of social ranking under conditions that favor simpler rather than more complex forms of sociopolitical organization.

Although many other research problems could be identified and discussed, these are some of the more obvious and prominent ones to which studies of subsistence-settlement systems of the Vandenberg region are relevant. It is important to recognize that no one archaeological project can provide data sufficient to resolve any one of these problems. Substantive progress in addressing these problems is the result of the accumulation of information through many projects and the resolution of many small and mundane problems along the way. This is especially so with regard to the Vandenberg region, where archaeological research is still in its infancy.

Models Of Chumash Subsistence-Settlement Systems

Intensive studies of subsistence-settlement systems are still relatively rare in California, and although there has been much hypothesizing about Chumash subsistence-settlement systems, substantive studies have been limited in scope. Landberg (1965) was the first scholar to give specific attention to Chumash subsistence and settlement. Using ethnohistorical, archaeological, and biological data primarily from the Santa Barbara Channel, he constructed a model in which the Chumash occupied coastal villages in late summer for marine fishing and through the winter to subsist on stored food resources, but dispersed to seasonal camps during the rest of the year to exploit a variety of terrestrial resources.

Building upon observations made by Landberg regarding seasonal movements of Santa Barbara coastal Chumash inland to obtain terrestrial food resources, Spanne (1975b) proposed that the Barbareno Chumash regularly moved to the Santa Ynez Valley during the winter months to fish for steelhead running in the Santa Ynez River. Conversely, Ynezeno Chumash were hypothesized to have moved to the coast during the summer to fish in the channel. Tainter (1971) proposed instead that the Barbareno and Ynezeno Chumash were linked in an economic exchange relationship in which Ynezeno would obtain marine fish from Barbareno during dry winters and Barbareno would obtain steelhead from Ynezeno during wet winters. Tainter also argued that Ynezeno Chumash practiced two different types of adaptations, one in which permanent villages were occupied along the Santa Ynez River and its major tributaries and the other, characterizing those Ynezeno living away from the river in the mountains, in which the settlement pattern was more flexible. In another paper, Tainter (1975) developed an argument that the Ynezeno Chumash villages exchanged food resources because of the significant differences in resources between the territories surrounding the villages in the availability of different classes of resources.

More recently, Horne (1981) proposed a model of subsistence and settlement for those Ynezeno Chumash occupying mountainous lands north of the Santa Ynez Valley. In his model, a series of high-altitude locations would have been occupied during the summer and into the fall, and lower-altitude locations in valleys served as base villages occupied during the winter.

While all these models have their merits, and all are consistent with the archaeological record insofar as it is known (excepting the proposition that steelhead were exploited in great numbers, for which evidence so far is

negative [Glassow 1979]), data have not been collected that would provide critical tests. In particular, little attention has been given to the careful excavation of village bases and seasonal camps with the objective of obtaining data regarding subsistence activities carried out at such sites and the season during which they were occupied. Macko (1983) has attempted to make progress in rectifying this situation in his analysis of data collected during the 1950s and 1960s from a Santa Ynez Valley village site, but the data available to him in the existing collections were not ideal. Furthermore, these models are specific to the Barbareno and Ynezeno and do not have clear applicability to the Purisimeno of the Vandenberg region.

Certain facts indicate that subsistence-settlement systems of the Purisimeno and their prehistoric predecessors were significantly different from the subsistence-settlement systems of the Barbareno Chumash and their predecessors. First, there are significant environmental differences between their regions. The coastline of the Vandenberg region is exposed to the prevailing winds and the southward moving California Current, whereas the southfacing Santa Barbara Channel coast is protected from both prevailing winds and the California Current. It is not surprising, therefore, that the Barbareno used plank canoes extensively to ply channel waters, but the Purisimeno did not, at least not north of Point Conception (A. Brown 1967:5-6). In other words, marine fishing from boats must not have been so important among the Purisimeno north of Point Conception as it was among the channel-dwelling Chumash. In addition, differences in the archaeological records between the two regions reveal differences in subsistence and settlement. Despite lower Purisimeno population densities at the time of European contact, sites are generally in much higher densities in the Vandenberg region than they are on the Santa Barbara Channel, which appears to reflect greater intersite mobility in the Vandenberg region. Glassow and Wilcoxon (1979) also point out that subsistence remains in late prehistoric sites of the two regions differ significantly, pointing to a greater emphasis on shellfish and terrestrial game in the Vandenberg region, but a greater emphasis on marine fishing along the Santa Barbara Channel. It is also clear that chipped stone tool manufacturing was a much more important industry in the Vandenberg region than nearly anywhere else in southern coastal California, as reflected in the abundance of chert flakes and cores in so many Vandenberg region sites.

The only specific consideration of subsistence-settlement systems in the Vandenberg region is Spanne's (in Glassow et al. 1976:44-50) attempt to model the pattern of Late Period village placement and intersite mobility. He noted that the only historic Purisimeno villages on the Vandenberg coast, Nocto and Lospe, are located on south-facing segments of coastline, which afford protection from the strong winds and surf and access to abundant intertidal life along local stretches of rocky shoreline. The other historic Chumash villages, he noted, were located several kilometers inland, where weather is more equitable, and relatively abundant oaks provide acorns. Since the stretches of coastline nearest these inland villages are exposed and of low

resource productivity, Spanne argued that populations from the inland villages moved down the major valleys in which the villages were located and then either up or down the coast to locations of rocky intertidal zones where shellfish could be collected. He argued that the populations living in the inland villages were largely responsible for the large numbers of small sites scattered along the coastal valleys down from the villages and along the unproductive stretches of coastline. He proposed that these were camps occupied during movement from the inland villages to the shellfish collection localities. The two coastal villages, on the other hand, were in positions allowing for relatively high degrees of sedentism.

The principal flaw in Spanne's model is his neglect of the potential importance to subsistence pursuits in the zones containing sm'l sites. It is highly likely that many of these sites were not occupied simply as way stations along routes of travel, but instead as seasonal sites from which hunting and collecting of terrestrial resources were carried out. Despite this shortcoming, his model is an important step in developing explanations of the geographic distribution of historic Chumash villages and the variations in the nature and distribution of sites along the Vandenberg region coastline.

An Approach To Studying Subsistence-Settlement Systems Encompassing The San Antonio Terrace

Against this backdrop of past considerations of Chumash subsistence and settlement, the project research design developed by Snethkamp (1981) and Moore (1982) proposes that a predictive model be developed in the course of research which would deal with three subjects having to do with subsistence and settlement. These subjects are: 1) settlement structure, 2) intrasite variability, and 3) resource procurement and use subsystems. Studies of settlement structure are concerned with discovering the manner in which human activities are distributed in geographic space and the determinants of these distributional patterns. Studies of intrasite variability take these investigations to a higher level of specificity in that the spatial patterning of human activities within site areas becomes the focus of attention. Studies of the third subject, resource procurement and use subsystems, go hand-in-hand with the first two since they would be concerned with the identification of the activities that would be considered in spatial analyses.

Settlement Structure: Studies of settlement structure are generally concerned with three interrelated topics: resource use schedules, site placement, and demographic arrangements (Jochim 1976). Each can be considered from the perspective of optimization theory, which has recently enjoyed considerable attention among anthropologists interested in hunter-gatherer adaptations (e.g., Winterhalder and Smith 1981). With regard to resource use schedules, for instance, the concern would be in developing a model that predicts seasonal changes in resource combinations exploited assuming that those resources exploited during a given season are those that yield the highest nutritional return for the effort expended in their exploitation. To make such predictions, information must be obtained on

the distribution and abundance of each potential resource by season, the nutritional values of the resources, and the amount of effort expended in exploiting each resource, which is usually measured as the time expended per person to obtain and process a given amount of each resource. The latter normally requires prior knowledge of resource exploitation technology. Site placement and demographic arrangement are, of course, dependent upon knowledge of resource use schedules. That is, once predictions have been generated regarding which combination of resources would be exploited during a given season, there are optimum locations and spacing of sites which minimize travel time to resource locales (Wilmsen 1973), as well as optimum group sizes (Smith 1981) and sex/age partitions of the populations for exploiting the resources.

Snethkamp and Moore proposed that an effective way to implement a predictive model based on these assumptions about settlement structure would be to superimpose a hexagonal grid over a map of the study area (and beyond), and within each hexagonal cell calculate the abundance and portability of each potential resource present. Ethnographic information on Chumash subsistence and technology would be used to identify potential resources and to determine exploitation efforts. Sources on nutritional values of food resources such as those used by Glassow and Wilcoxon (1979) would be consulted to calculate nutritional returns. On the basis of this information, predictions would be made regarding the relative importance of each type of resource present in a given cell, the kinds of activities that should have occurred, and the archaeological correlates of these activities. An effort would also be made to predict the season and duration of occupation within each cell. The duration of occupation is argued by Snethkamp to be function of frequency and diversity of processing and maintenance activities and the importance of degree of dependence on the particular resources present.

Intrasite Variability: The occurrence of sites in sand dunes which have been active at times during the course of prehistory implies that episodes of occupation may have become stratigraphically separated from one another by shifting sands. Snethkamp and Moore recognized this possibility and argued that the investigation of intrasite structure may be especially productive on the San Antonio Terrace. Indeed, the archaeological debris preserved as a stratum or lens within dune deposits could conceivably represent only a day's or even a few hours' worth of prehistoric activity. The investigation of sites representing very short durations of occupation could produce data relevant to isolating particular activities and their debris, the spatial patterning of site activities, and the size and demographic composition of the occupying group. While such studies are becoming common in regions of North America where preservation conditions are relatively ideal (e.g., the American Southwest), they are not common in California, largely because of the ephemeral nature of architecture and adverse soil development processes, especially faunalturbation. Consequently, sites within the dunes may present an unusual opportunity for California archaeology. (It should be noted,

however, that the opposite phenomenon can occur in dune sites, that is, wind deflation can result in collapsing several distinct occupational strata into one, as discussed by R. Brown in Chapter 5.)

Resource Procurement and Use Subsystems: As mentioned, studies of spatial variability in prehistoric activities require that these activities be reconstructed. The archaeological record of the San Antonio Terrace provides data relevant to two classes of activities concerned with resource procurement and use: the acquisition, manufacture, and use of chipped stone tools and the acquisition, preparation, and consumption of floral and faunal food resources.

Chipped Stone: Datà reflecting the use and manufacture of chipped stone tools comprise the most obvious and abundant class available from the project investigations. These data take the form of tools (or parts of tools) used to obtain game animals (such as projectile points), various types of flake tools used to process game animals and perhaps also plant products, and waste flakes and (less frequently) cores that are the by-products of tool manufacture and maintenance. The study of the chipped stone therefore falls into four topics: identification of the sources of raw materials, description of the technology of chipped stone tool manufacture and maintenance, identification of the functions of stone tools through the study of their morphology and use-wear along working edges, and analysis of the spatial contexts of material procurement, tool manufacture and maintenance, and tool use.

Regarding the sources of stone used for chipped stone tools, nearly 100 percent of the stone materials in the collections is Monterey chert, which occurs in a variety of colors and qualities. Under the assumption that color and quality of chert might be peculiar to particular bedrock sources, it is possible that particular sources were used for the manufacture of particular kinds of tools. It is also possible that the spatial distribution of chert identifiable to specific, geographically delimited sources might reflect the use of the San Antonio Terrace by particular social groups in whose territory the source occurs.

The production of chipped stone tools and their maintenance can be studied through the morphological characteristics of the waste flakes and cores that are the by-products of tool manufacture, as well as the tools themselves. It was already apparent by the time the research design was prepared that tools and cores are rare in San Antonio Terrace sites but that waste flakes are potentially very abundant. Furthermore, the waste flakes appeared to represent primarily the final stages of tool manufacture or perhaps edge resharpening. A specific objective of the analysis would therefore be to identify whether the flakes are related to tool manufacture or edge resharpening and the kinds of tools from which the flakes were removed.

The identification of use-wear on the edges of stone tools would allow certain procurement and processing activities to be identified. Activities that could be reflected by use-wear characteristics include butchering of game

animals, scraping or sawing wood or bone in the process of making tools of these materials, and cutting or pulping plant products for consumption or for the manufacture of such artifacts as baskets.

Information on the spatial patterning of tool manufacture and maintenance and of tool use are relevant to analysis of both settlement structure and intrasite variability. Sites exhibiting greater diversity in these activities are most likely to be those at which the duration of occupation in the course of annual round was longest. Furthermore, the kind and intensity of food exploitation activities reflected by the tools should correlate with those activities predicted for the hexagonal cell in which the tools were found.

Floral Remains: Floral remains encountered in sites, normally as carbonized plant parts obtained through fine-mesh screening of deposits or through flotation, are potentially a direct product of subsistence activities. As such, the species of plants represented and the abundance of their remains would bear on the analysis of settlement structure and intrasite variability. Floral remains identifiable to species may also be important to paleoenvironmental reconstruction, if it can be assumed that the plants were collected locally.

Faunal Remains: Two classes of faunal remains occur in sites on the San Antonio Terrace: bone and shell. Like floral remains, faunal remains can be assumed to reflect subsistence activities, and they are also relevant to the different aspects of the spatial analysis. For bone remains, species identifications are necessary to determine the extent to which animals available in the environment immediately surrounding the site (principally deer, rabbit, various rodents and various waterfowl) were being exploited. Butchering practices may be exhibited as cut marks on the bones or in the patterning in the occurrence of skeletal parts. If such evidence is present, it may be possible to differentiate between a site that is a temporary camp from which most of the animal carcass was carried off and a village site where the greater part of the animal carcass would have been consumed.

Some of the species represented in the bone remains may be of marine fish or sea mammals. Both would reflect importation of food resources from the coast, and they would expectably be most prevalent in sites occupied for weeks or months as opposed to sites occupied for a few days or even less time.

Shellfish remains found in San Antonio Terrace sites reflect clearly exploitation of a resource zone some distance from sites. Not only are the sites in the project area several kilometers from the coast, they are even greater distances from shellfish beds at Point Sal and Purisima Point, where the species most abundant in the sites, mussel (Mytilus californianus) and turbans (Tegula sp.), occur. Sites with relatively high densities of shellfish remains would probably have been used for longer durations, as would also be the case if marine mammals or fish remains were present. The particular species of shellfish represented at a site, as well as the size of the shells, may reflect patterns of exploitation in that some species and size ranges would be most accessible during particular seasons of the year.

Unfortunately, none of the species known to occur abundantly in the sites is one of those which exhibit distinct seasonal or annual growth rings. If such species (e.g., Tivela and Chione spp.) were present, the season of collection could possibly be ascertained.

The Impact of Paleoenvironmental Change on Subsistence-Settlement Systems

The presence of stabilized dunes on the San Antonio Terrace with very fresh morphology (the intermediate dunes), as well as the active dunes along the coast which are in some places advancing inland, implies the existence of distinct environmental events during the course of prehistory, such as major fires or, more likely, periods of less rainfall causing the stabilizing vegetation to diminish. Sites on the intermediate dunes are, of course, no older than the dunes, and sites that may be underneath these dunes (none has so far been found) must date no later than the formation of the dunes. If dates can be obtained from sites on or under the dunes, the climatic event (or events) related to dune advance can be bracketed in time. It may also be possible to obtain organic material from the dune deposits themselves which could be dated through the radiocarbon method. In either event, it would be helpful to know when the dunes formed, for their formations would have had a profound effect on the natural environment of the terrace. While the species composition of the flora and fauna may not have changed significantly with the emplacement of the dunefield, their distributions would. Distinct pockets of wetlands would have been formed between some of the dune ridges, and these would have attracted certain fauna such as deer, as well as the prehistoric peoples who hunted them.

There is also the possibility that the intermediate dunes are not as stable as they seem. There may have been incremental advances which had a significant local effect on the topography. In particular, some wetlands may have been covered over while others were created. Such changes would have had some impact on prehistoric land use on the intermediate dunes.

For these reasons, the project research design recognized the importance of understanding the chronology and processes of intermediate dune formation. The current distribution of sites on the San Antonio Terrace, both on and near the intermediate dunes, could be reflecting in part environmental conditions that no longer exist. If the analysis does not compensate for the effects of these conditions, the results could be meaningless.

Another important factor to consider is the impact of climatic cycles on the distribution of flora and fauna after the time the intermediate dunes became stabilized. Higher than average rainfall, such as occurred during the winter of 1982-1983, produces striking changes in the vegetation covering the dunes. Introduced grasses are more prevalent, there is significantly more growth on the scrub vegetation, and wetlands and associated vegetation occur in swales that are normally dry. On the other extreme, lower than average rainfall appears to cause otherwise perennial wetlands to dry up, a condition observable on some of the early air photos of the project area (see

Chapter 5). Again, shifts in the distribution of resources caused by climatic fluctuations must be considered in the analysis of prehistoric land use patterns.

While major climatic changes are likely to have been involved in the formation and stabilization of the dunes, they would also have had an effect on the environment of the whole Vandenberg region. The project research design proposes that the paleoenvironmental records generated from the sediment cores from the bottom of the Santa Barbara Channel may serve as a basis for predicting the nature of the climatic changes and their effect on regional environment. They may also shed some insight on when the dunes were active. Pisias (1978, 1979) used the abundance of radiolaria species to construct a sea-surface temperature curve for the last 8,000 years. Since sea-surface temperature has a close relationship to air temperature and presumably also rainfall (Pisias 1979), a broad outline of weather patterns through most of prehistory can be reconstructed. The sediment cores also contained fossil pollen, which Heusser (1978) used to document changes in plant communities along the Santa Barbara Channel over the last 12,000 years.

Pisias' sea-surface temperature curve reveals that current sea-surface temperatures are significantly cooler today than they have been throughout much of prehistory. Periods of warmer than average temperature occur between 800 and 1,900 years ago, 3,400 and 3,900 years ago, and 5,400 and 8,000+ years ago (calculated in calendar years). Pisias (1979) argues that warmer water temperatures correlate with higher rainfall, and this is the position taken by the project research design (Moore 1982). However, the prevailing opinion appears to be that warmer sea-surface and air temperatures correlate with less rainfall (Axelrod 1981; James West, personal communication). Actually, both positions may be true. The longer-term fluctuations persisting for hundreds of years may be between warm-dry and cool-wet conditions, but shorter-term fluctuations persisting from year to year and decade to decade may be between warm-wet and cool-dry conditions. In any regard, the prediction of the course of climatic change, and therefore environmental change, through the course of prehistory appears to be more complicated than originally proposed in the research design. Assuming that the periods of dune activity can be at least roughly dated, an assessment may be made of which pattern of longer-term fluctuations appears to be correct.

Some of the archaeological data may be quite sensitive to environmental change and therefore would be independent indicators. Floral remains could be of species indicating the presence of vegetation no longer present in the region. A more likely possibility is the occurrence of temperature-sensitive shellfish and fish remains. For instance, the giant chiton, <u>Cryptochiton stelleri</u>, is a known inhabitant of cool water, and the presence of fish of the tuna family are indicators of relatively warm ocean temperatures.

The impact of major climatic changes on the distribution of food resources may have affected not only the locations at which settlement took place in the dunes but also whether any settlement at all was possible. If,

for instance, a climatic phase was characterized by significantly less rainfall, the dunes may have become more active and wetlands may have been largely nonexistent, thus minimizing the attractiveness of the intermediate dunes as a resource area. The data analysis must therefore give serious consideration to the possibility of significant climatic changes at times during prehistory.

Postdepositional Processes

The presence of sites on dunes that clearly have been active at some time during prehistory implies that site deposits may have been affected by aeolian processes. Many sites with dense midden deposits adjacent to the coast clearly have undergone deflation, which leaves pavements of shellfish remains, chert flakes, and fire-altered rock on the site surface. More subtle alterations are suspected to have occurred to sites inland on the intermediate dunes. Some sites, SBa-1193 as an example, appear to be comprised largely of sand-polished chert flakes up to five millimeters long which have blown into a locale from upwind. In other words, certain sites or portions of sites are actually secondary deposits of flakes small and light enough to be carried by the wind. Small pieces of bone and shell are also capable of movement by the wind, although they would not be carried as far as flakes before disintegrating. Even if relatively durable objects are too large to be moved by the wind, their surfaces can become highly polished through sand abrasion if they remain on the surface for very long. Because these processes have certainly affected sites within the project area, means must be developed for identifying aeolian disturbances and compensating for their effects on the archaeological record.

Another major site disturbance process is the burrowing of gophers, ground squirrels, badgers, and other animals into site deposits, or what Wood and Johnson (1978) call "faunalturbation." Krotovina (filled-in rodent burrows) were especially obvious in two of the sites excavated early in the project, SBa-1036 and SBa-1170. Unit sidewall profiles of the deposits revealed that krotovina comprise 50 percent or more of the deposits at these sites. Faunalturbation appears to be especially prevalent in sites on the old dune surfaces and significantly less prevalent on the intermediate dunes, apparently because of the loose sand matrix. The expectable effects of faunalturbation include the lateral and vertical displacement of cultural items and the blurring of stratification of the deposits and archaeological features such as hearths. In addition, burrowing animals can introduce foreign objects into a deposit, including themselves when they die in their burrows or dens. It is clear, then, that the analysis of intrasite variability and faunal remains must compensate for the potentially serious effects of faunalturbation.

Historic Cultural Resources

The project research design did not specifically address the fact that historic archaeological resources were present in the project area, and indeed at the initiation of the Vandenberg MX Archaeological Project these were not expected to be encountered during fieldwork. However, at SBa-1174 the

remains of a wood frame structure and an adobe-walled structure were discovered, and the removal of a large eucalyptus tree in connection with power line emplacement impacted the trash area immediately downhill from adobe ruins. Mitigation of these impacts involved collection of historic artifacts from the disturbed trash deposits and definition of the integrity and extent of the adobe ruins. Having obtained these data from SBa-1174, two elements of research were added. First, the historical overview presented in Appendix II was expanded to include research into any known history of the ownership and use of the adobe building. Second, the collections of historic artifacts were submitted to a historical archaeologist for analysis aimed at determining dates of the use of the structure and its function. A specific objective of both research elements was to determine whether the structure was the adobe occupied by the Olivera family as reported in the 1870s by the archaeologist P. Schumacher.

ADJUSTMENTS TO THE RESEARCH DESIGN FOR THE DATA ANALYSIS

The project research design developed by Snethkamp and Moore is best thought of as a regional research design not tied to a specific body of data collected from the San Antonio Terrace. It takes into consideration what would be possible to accomplish on the basis of what is known about the archaeology and environment of the San Antonio Terrace, but its data requirements go far beyond the data generated by the Vandenberg MX Archaeological Project. It is important that such a regional research design exists and that it be updated and refined in the future, but the realities of what kind of research can be accomplished with the data at hand must be confronted in the course of designing the analysis.

It is appropriate to begin by specifying where there are data deficiencies and how these affect the analysis. The project research design specifies that a predictive model of settlement structure be generated using information on the distribution of resources on the San Antonio Terrace. While there has been extensive survey and mapping of vegetation communities, including specifically wetland communities on the San Antonio Terrace (the Environmental Planning System developed by the Center for Environmental Studies, San Diego State University [Coulombe and Cooper 1976]), the botanic data are not sufficiently specific for purposes of plotting the distribution and abundance of potential food resources. To generate data of the specificity needed would be a time-consuming and expensive undertaking, even if field biological survey time was minimized through the use of air photographic remote sensing. As a consequence, there is currently no basis for developing a predictive model of settlement structure, at least not along the lines proposed in the project research design. Added to this problem is the fact that dune activity during prehistory likely changed microenvironmental characteristics significantly, which means that present-day environmental conditions may not in every case be good predictors of settlement structure characteristics.

Another deficiency in the data necessary for studying settlement structure is the lack of a sample of identified and adequately documented sites representative of the whole study area. Surveys previous to the Vandenberg MX Archaeological Project appear not to have penetrated the intermediate dunes to any significant extent, and when they did, smaller sites with low densities of surface materials were apparently overlooked. Consequently, patterning in the distribution of sites within the study area simply cannot be discerned at present. Furthermore, the sites from which subsurface information is available are restricted to a small portion of the study area. Even if survey data were representative, the excavation data would still not be, and clearly these data would be needed in order to characterize adequately the kinds of subsistence activities which took place at a site.

Investigation of the impact of environmental change and short-term fluctuation is similarly thwarted. Research on this topic would require detailed environmental information as well as considerable control over chronology. While the research design as originally conceived proposed that periods of less rainfall correlated with increased dune activity, it must also be recognized that if increased rainfall results in more sand flowing down the rivers and streams north of the San Antonio Terrace (the Santa Maria River in particular), more sand will be available on local beaches to be blown inland. Under this hypothesis, the stabilizing effect of lush dune vegetation may have been irrelevant to the formation of a new series of dunes. On the other hand, increased rates of beach sand accumulation may have occurred during relatively dry rather than wet periods, since those rains that do occasionally fall during droughts would potentially have substantial erosive power within the area of the watershed.

The lack of much chronological data for both paleoenvironmental and archaeological phenomena presents another problem. Only three of the sites in the project area have been dated by means of the radiocarbon method, and dating of several others on the basis of distinctive projectile point types is on tenuous grounds. Attempts were also made to date the antiquity of the intermediate and old dunes, but a number of complications were encountered, as discussed by Johnson in Chapter 4.

Studies of intrasite variability require areally representative samples from sites, as well as block excavations where living floors or other areally extensive features are encountered. The only excavation of this type was done at SBa-1179, and although an attempt is made to investigate intrasite structure at this site, the sample of sites at which this type of excavation was done would have to be much larger for consistent patterns to emerge.

The analyses of the collections with the purpose of defining resource procurement and use subsystems are constrained to some extent by the small numbers in each category. Although this is due in part to the low densities of cultural items in sites of the study area, it is also a product of the limited excavations at most sites in the project area. Furthermore, the excavated samples obtained from the sites vary in size, proportion of the universe of

cultural items, and representativeness of the density variations within the site. These problems mean that comparisons between sites must be limited to relatively gross differences and that some sites simply have to be eliminated from aspects of the comparative analyses.

On the positive side, the data do allow for some interesting research to be accomplished. The investigation of settlement structure can proceed by employing fewer variables and a simpler quantitative approach to the analysis. Distances of sites from major resource areas would be worth investigating. Three major resources areas can be defined: the coastline, where marine resources are available; the San Antonio Creek bottomlands, where marshland resources and game animals are abundant and reliably present; and the perennial ponds located near the northern end of the project area in the intermediate dunes.

The studies of the lithics and faunal remains can proceed generally as planned, even though some limitations to intersite comparisons must be imposed by the problems with sizes of site collections and representativeness of the samples. Therefore, sites can be tentatively classified into settlement types on the basis of subsistence and production/maintenance activities represented, and this information can then be used to study settlement structure using the simplified approach discussed above.

The study of postdepositional processes can also proceed as planned, not only with respect to identifying the processes themselves but also with respect to the impact of these processes on different aspects of the archaeological record. This is potentially one of the greatest contributions that the Vandenberg MX Archaeological Project can make to regional archaeology. Once these processes and their impacts are understood, future archaeological investigations on the San Antonio Terrace and other similar dunelands will be on a much firmer footing.

Chapter 3

NATURE OF THE INVESTIGATIONS

INTRODUCTION

As stated in Chapter 1, the objectives of the Vandenberg MX Archaeological Project were 1) to discover archaeological sites and delimit the boundaries that might be affected by construction of MX test facilities 2) to evaluate the significance of the sites for determination of their eligibility for inclusion on the National Register of Historic Places, and 3) to mitigate any unavoidable impacts to sites. These objectives were accomplished through four sets of activities; fieldwork, collections processing, data management, and data analysis. In this chapter these activities are described in order to document how the data used in the analyses presented in this report were generated.

Field activities involved the application of a variety of procedures with overlapping purposes. The bulk of the field effort was devoted to survey, which involved initial on-foot reconnaissance, intensive on-foot survey along transects spaced at varying distances, mapping of surface finds, and the excavation of shovel test pits (STPs). The latter procedure was necessary because many site deposits were obscured by relatively thin mantles of wind-blown sand. In the context of survey, STP excavations served as a site discovery procedure in situations where surface observation was not sufficient. At or near the time a site was discovered, efforts were made to define its boundaries. This was usually done through a combination of surface survey and STP excavations. Because investigations were limited to areas of potential construction impacts, the actual boundaries of sites were defined in only eight instances, and in three of these only a portion of the site boundary was defined.

In some cases, as when impacts to a site could be avoided, no further work was undertaken at a site once its limits within a potential impact area had been determined. When impacts were likely or certain, unit excavations, usually one meter square, were often undertaken to determine whether mitigation of impacts through more extensive excavation was justified, or in other words, to determine whether the site was significant in terms of National Register criteria. When surface indications or data from STPs was sufficient for significance determination, test units were meant to collect data relevant to calculating the scope and cost of mitigation excavations. The Vandenberg MX Archaeological Project included investigations at a total of 41 sites, subsurface investigations taking place at 24 of these.

Unit excavations for the above purposes sometimes merged with excavations for the purpose of impact mitigation. For that matter, all investigations at a site, whether for boundary definition or assessment of contents, contributed to the mitigation of impacts at those sites affected by construction activities. When impacts were minimal or archaeological resources were in low densities, investigations initially designed for the purposes of assessment were construed sufficient for mitigation as well.

The block excavations undertaken at SBa-1179, a site completely destroyed by road construction, were the most extensive at any site for the purpose of mitigation of impacts. This was also the site most heavily impacted by some form of construction. At other sites where formal mitigation excavations took place, dispersed units were deemed sufficient.

Monitoring earth-moving construction activities, especially at known sites, was also an important part of the mitigation program. Nearly all of the construction monitoring was performed by VTN Consolidated under the direction of L. Spanne. CCP field personnel participated in construction monitoring only where there was some possibility of obtaining data that would complement that obtained earlier from a particular site, including soil profiles and soil samples.

The field laboratory was always an integral part of the overall field operation. Prior to CCP's involvement with the project, field laboratories were located at UCSB for those investigations undertaken by UCSB-OPA or at the HDR Santa Barbara offices for those investigations handled directly by HDR field personnel. In both instances, the field laboratory was in operation during the course of investigations, or after comparatively small increments of fieldwork had been completed. CCP's field laboratory was located in Lompoc, and field laboratory activities were continuous through the period that CCP was collecting field data.

The field laboratory carried out several important duties. First, it processed all collections from the field on a daily basis. Second, it checked all records pertaining to the collections for completeness and consistency of information, especially information on provenience of the collections, controlled primarily through the use of lot cards. Third, it served as a temporary repository for collections and records. Fourth, it was the location where field personnel completed various aspects of field recordkeeping, including preparation of site maps. Finally, it served as the locus for staff meetings for purposes of planning and project management.

Once the bulk of the field investigations had been completed, the field laboratory was moved to commercial building space in Santa Barbara, and its functions shifted towards the compilation and analysis of data. The most important activity in the CCP Santa Barbara Laboratory was the preparation of Basic Data Reports (BDRs), a deliverable specified in the project contract. These reports are simply a compilation of all records pertaining to investigations at each site. Each BDR includes field notes and associated records, the site map or maps, the photographs and photographic catalog, tabulations of data on lot cards, and a short narrative describing the history of

investigations and the nature of the findings. The preparation of BDRs was an effective means of insuring that all field and laboratory records were in order. Another activity performed at the Santa Barbara laboratory was the preparation of updates to the discontiguous district nomination to the National Register of Historic Places. This required revising site record forms in a light of further investigations and impacts sustained through construction and plotting new information on a map of the discontiguous district. Associated with the National Register nomination updating was the compilation of a site-by-site overview of the study area. For all sites at which some form of investigation beyond recording took place, information was compiled on the nature of these investigations, the nature of the findings, and the current condition of the sites. This overview satisfies in part the requirement in the California Office of Historic Preservation's "No Adverse Effects" determination that a comprehensive study of the project areas's prehistory be undertaken.

Several activities specifically associated with the data analysis also took place at the Santa Barbara laboratory. The collections were segregated into those classes to be the subject of separate analyses (shellfish remains, osseous remains, lithics, historic artifacts, geological samples), and these were eventually transferred to the individuals performing the analyses. The analysis of soil samples presented in Chapter 6 was carried out at the laboratory by CCP personnel under the supervision of geologist T. Rockwell, and a pilot flotation project was undertaken to determine whether carbonized seeds of aboriginal origin were present in soil samples from the more promising sites. Draft and, in some cases, final copies of various illustrations for this report were also prepared.

All archaeological collections and associated field and laboratory records will be housed at the UCSB Department of Anthropology.

DATA COLLECTION PROCEDURES

General Approaches

Data collection procedures employed during CCP's archaeological investigations followed closely the general descriptions below. Some variations were incorporated either to enhance the efficiency of field work in general or to accommodate the idiosyncracies of particular sites or areas. The bulk of the changes in field procedure were incorporated at the onset of the second phase of the project in June 1981, some of them more successful than others. A site-by-site discussion of the variations follows the general description of procedures.

Survey: Surveys were undertaken where impacts were expected and no sites were known to exist. Two survey methods were employed for the majority of the project's duration: surface survey and sub-surface survey.

Surface Survey: Two surface survey procedures were used: systematic, which was used in all zones of impact, and unsystematic, which was used in areas not threatened by direct project impacts. The object of the

systematic surveys was to discover all sites in the threatened areas. Unsystematic surveys were done to gather additional information about specific sites and/or research questions.

Systematic surface survey involved the close examination of the surface by crew members slowly walking parallel transects. HDR's survey interval was 15 m while CCP's survey interval was in no instance greater than 5 m and at SBa-1193, -1155 and the SSF project areas the interval was 3 m. Such unusually close interval examination was demanded by the reduced visibility of archaeological deposits in the dunes caused by rapid deposition and deflation (see Chapter 5 for discussion of the impact of aeolian processes on sites).

Cultural material was flagged on discovery. The locations of finds were later determined with precision by triangulation to prominant landmarks at permanent buildings. Each discovery was bagged and assigned a lot number and accompanying lot card for future reference.

Unsystematic surveys were conducted occasionally in response to specific problems. For example, during the sub-surface survey of the fiber-optics cable route along Bass Road, archaeological materials were found between SBa-1070 and -980. Subsequently, materials were found during casual walk-overs to be distributed without break (indicators were everywhere less than 50 m apart) between SBa-1070 to the north, through the materials found in Bass Road and on into SBa-980. Other unsystematic surveys demonstrated that SBa-980 and -1070 were central portions of a very large site extending 2 km from the south rim of the San Antonio Creek drainage into the central portion of the intermediate dunes.

Three sites (SBa-1727, -1728, and -1729) and extensive unrecorded deposits extending between SBa-721 and -512 were discovered along the various routes to and from locations frequently visited during post depositional analysis field work.

Collections of high quality aerial photographs are available at the Base Environmental Office, UCSB, and at Whittier College. No photographic features were seen to be directly indicative of the presence of prehistoric cultural materials in the San Antonio Terrace dunes. However, areas are apparent which are more likely than others to contain sites. For example, the lag deposits ("dune pavement") (see Chapter 5) are often artifact rich.

Sub-surface Survey: Ground cover, shifting sands and the small size of many of the artifacts prompted the use of sub-surface survey techniques. These methods were not designed to test areas, but rather to allow closer examination of the soil's constituents as a site-discovery technique. Sub-surface survey involved the excavation of STPs at 50 m intervals. Each STP was excavated to a depth of at least 50 cm and the excavated material was screened through 1/8 inch hardware cloth. Screen residuals were sent to the laboratory for processing.

The locations of all STPs were marked in the field either with a numbered stake or flagging. The field crew was notified when laboratory sorting revealed that a particular STP had been productive. The field crew

returned to the location of the productive STP and conducted a test for isolation. (Tests for isolation are considered here because they were used during the various survey phases of the project and because their objective was not the evaluation of sites but the determination of whether a site was present. Their use is a refinement of the site finding process.)

Tests for isolation were designed to determine whether an artifact found on the surface or recovered from an STP occurred in isolation or in a possible site context. The surface of the area immediately surrounding an isolated find was examined once again for additional artifacts. If none was found, an array of STPs was excavated around the original find. In the eastern shelter area eight STPs were placed, four of which were 5 m away in each cardinal direction and four of which were 10 m away. Along the FOCL only four additional STPs were excavated in the test for isolation. Two of these were placed 5 m and two 10 m from the productive STP on a line parallel to the axis of the survey corridor. The test was terminated on the discovery of an additional artifact, and the location was given tentative "site" status. If no additional cultural materials were found in any of the additional STPs, the initial find was considered an isolate.

Survey Collection: Surface materials were collected only if they were threatened by construction disturbance or if they had clear diagnostic value. Provenience was recorded with a Brunton compass or transit and metric tape or stadia rod. Each artifact was assigned a lot number and a surface collection number in the field, prior to being sent to the laboratory for processing.

Shovel Test Pit (STP) Excavations: Two methods of STP excavation were employed. Early in CCP's involvement in the project STPs were excavated in two 40 cm levels and the matrix was sifted through 1/16 inch screen. This technique was abandoned at the onset of Phase II because level control was impossible in the sand matrix. Single-level STPs excavated to 50 cm were substituted and soils were screened through 1/8 inch screen.

STPs were used in a variety of contexts. As was mentioned above, STPs were used as a site finding technique. They were also used extensively in testing and to a more limited extend in data recovery. In the testing of sites, STPs were most often employed in site boundary definition.

Site boundary definition involved the placement of STPs at 20 m intervals beginning at the most peripheral cultural indicator and proceeding in a line away from the site center. Once two sterile STPs had been excavated, three additional STPs were excavated at 5 m intervals between the last productive STP and the first sterile STP proceeding away from the center of the site. If any of these last three STPs was productive, another was excavated 20 m beyond the farthest. The process continued until the farthest STP from the site's center boundary was drawn through the productive STP. The site's boundary was drawn through the productive STP farthest from the site's center. Since this procedure was used only along the FOCL lines and in the eastern shelter block survey area, only eight sites were tested in this manner.

STPs were also used to acquire information concerning the intra-site distribution of materials. Lines or grids of STPs, excavated at various intervals, were arrayed within a site's boundaries. The locations of materials recovered by this method were mapped, and the distributions seen guided the placement of subsequent test units.

Unit Testing: The primary intra-site testing strategy involved the excavation of 1 m^2 test pits. The placement of test pits within SBa-1193 was determined randomly, using numbers generated by throws of a 20-sided die on which each digit is represented twice. Numbers so generated represented the coordinates of a grid which had been previously superimposed on the site. Non-random placement was judgmental, based on the distribution of surface materials and STP results, or the location of point impacts such as power pole placements.

The excavation of test pits proceeded in either 10 cm or 20 cm arbitrary levels. Each level was assigned a separate lot number by which all materials collected from that level were subsequently referenced. Excavation was continued to sterile soil or when unit side wall collapse made level control impossible. At SBa-1193, a backhoe was used to step back the side walls so units could be continued below the point where wall-fall would normally force pit closure.

When possible, the matrix was water screened in the field through small mesh screen (1/16 inch or 1/8 inch). Otherwise dry-screening was employed. In the eastern shelter area the initial procedure involved field sorting of materials with only cultural material being sent to the lab for processing. Because it was believed that more systematic sorting could be done in the lab, the procedure was changed in other construction areas to one of sending all screen residuals to the lab.

With few exceptions, a soil sample was collected from each level excavated; samples varied in size. These were bagged in the field and taken to the lab for processing. Column samples were also taken from selected units. A 10 cm^2 column was taken from the side-wall of the unit in levels which corresponded to those of the unit itself. Columns were bagged and sent to the lab for storage.

One STP to 40 or 80 cm was excavated at the bottom of most test units to determine sterility. A lot number was assigned to each STP level. Screen residuals were sent to the lab for processing.

Variations Between Sites and Project Areas

The discussion which follows details how the methods of data collection at particular sites and project areas departed from the general data collection techniques described in the preceding section.

Survey: Sub-surface survey with STPs was not done early in the project. It was first implemented in March 1981 at SBa-1193 after 3 m interval surface survey had been unproductive. Only surface survey was done at the RTF and SSF project areas, since this field work was completed

prior to the adoption of subsurface survey. Although the surface survey interval used by CCP was normally 5 m, at SBa-1193 and during the initial eastern shelter corridor surveys the interval was reduced to 3 m.

A grid of 51 survey-level STPs were placed at 10 m intervals at the MMF Parking Lots.

For economy, the number of STPs excavated in tests for isolation was decreased from eight in the eastern shelter block survey to four in the FOCL survey. Two were excavated at 5 m intervals in either direction from a find along the cable route.

Surface Collection: Surface collection procedures remained the same throughout the project. However, the collections made at SBa-1174 in the wake of the Base Civil Engineers' attempt to bulldoze down a large tree were not regulated by these procedures since these collections were obtained from backdirt greatly displaced from their original locations by the bulldozer .

STP Excavations: Variations occurred in both the method of excavation of STPs and in their method of placement. As was mentioned above, the early STPs were excavated in two 40 cm levels. Two-level STPs were dug at SBa-1193,-1709H,-1778,-1155, and -1070E. All other STPs were excavated in single 50 cm levels.

The justifications for the placement of test level STPs varied considerably. Of the 273 STPs excavated at SBa-1193, 82 were placed at the discretion of the field director at 3 m and then 5 m intervals along transects across the site. Four were focused at the location of surface finds, and 187 were placed as apart of a stratified random sample.

The placement of STPs at differing intervals along intrasite transects occurred at a number of sites. STPs were excavated at 5 m intervals at SBa-581, -1682, -1683 and -1684; 10 m intervals at Weather Station, SBa-1709H, -1778, and -1155; at 5 m intervals at SBa-998, and at 5 m, 10 m, 20 m and 50 m intervals at SBa-706.

Unit Testing: As with the STPs, 1 m^2 test units varied in both their method of excavation and the justification for their placement. Variations in method of excavation included the occasional substitution of water screening for dry screening, variations in screen size, and differences in the size of levels. An additional variation was incorporated along the 69 KV line. These units (at SBa-1174 and -1175) were excavated to at least 1 m at locations within site boundaries where power poles were to be emplaced.

Water screening was used at SBa-1052 (three units), -1174 (three units), and -1193 (all units). All other units were dry screened. In March 1981 the screen mesh size was changed from 1/16 inch mesh to 1/8 inch mesh with a 1/16 inch sample. This was done to save time in both the field and laboratory as screening with the smaller mesh was very time-consuming, and the relatively greater bulk of residuals greatly increased sorting time in the lab. At the same time, level constraints were changed from 10 to 20 cm to save time and to conform with other work done previously on Vandenberg, notably in conjunction with the Space Shuttle on south base (Glassow 1981), at SBa-1036 (Ford 1980) and prior work at MAB by HDR and UCSB-OPA.

Monitoring

Construction monitoring was preformed by VTN and CCP, with VTN doing the majority of this work. VTN's methods involved the direct observation of mechanized excavations and the occasional screening of disturbed matrix from backdirt piles and occasional collections. CCP's monitoring at SBa-1155 included only observation. At SBa-706, however, CCP's monitoring included observing the ditching, screening, profiling at 100 m intervals, and taking of column samples at 100 m intervals.

Field Record Keeping

The primary means of keeping track of all excavation units and material collected in the field was by the use of lot cards. (These are discussed fully in the section on laboratory procedures.) Additional records, including information not recorded on the lot cards, served to organize information contained on several lot cards. For example, a particular unit form listed the lot numbers for all the levels from that unit.

Unit Records and Notes: Unit records were completed in the field during the excavation of 1 m^2 test units. Space was allocated on the form to record the unit's size, location, method of excavation, names of excavators, and a drawing of a profile or plan view. For each level excavated, data were recorded concerning lot number, cultural materials recovered, and soil color and consistency. Continuation sheets were available for additional drawings if they were deemed necessary.

Journal and Related Records: The daily field report was completed on a daily basis by alternating crew members. On this form were recorded a description of the day's work, including a list of all units excavated, areas surveyed, names of crew members, and any other information bearing on the conduct of the field effort.

Maps and Mapping Techniques

Locational work is particularly difficult in an area as topographically complex and developmentally dynamic as the San Antonio Terrace. The relatively unstable nature of the dune landscape and the redundance of dune features made the use of terrain features as locational referents unwise. Added to this, landmarks usable as reference points for triangulation were frequently either modified or obscured by the construction of additional facilities, and the plotting of newly installed facilities on the 1 inch = 400 feet SAC maps (such as MAB which is now an ideal reference point) lagged behind their construction on the ground. Errors such as the Base Civil Engineers' mapping of the road to the Eastern Shelters more than 50 m west of its actual location further complicated locational work as did the variations in distortions of projection between the SAC maps and the USGS 7.5 minute quadrangle maps.

Locational control was accomplished by several methods. A licensed surveyor was hired to establish control points in the Eastern Shelter area; these were positioned on dunetops to allow their subsequent use as references

in triangulation. Site locations, isolated finds, turning points on the FOCL and some excavation units such as the STP lines in the Eastern Shelter area were triangulated to permanent, prominent landmarks or to previously set control points with either transit of hand-held compass. The locations of collected surface items, intrasite features, and excavation units, as well as STPs in the Eastern Shelter area and along the FOCL, were measured from loci previously located by triangulation by either transit and stadia or compass metric tape.

Photography and Photographic Records

Photographs were taken of all sites, features, major excavation units, and of topographic features to illustrate post-depositional processes. Thirty-five millimeter color slides were the primary format. Photos taken of test units and sites were backed up by 110 black-and-white photos. Film was commercially processed. If the processing of the slides resulted in a satisfactory record, the black-and-white film was discarded unprocessed.

In all unit photos, the subject, scale, and orientation were indicated. A photographic record was maintained which included the film type, subject, and orientation of each exposure.

LABORATORY PROCESSING PROCEDURES

Introduction

Different laboratory methods were employed by the several different contractors during various phases of the Vandenberg MX project, and the long duration of the project and changing project goals were additional complicating factors affecting laboratory procedures. The various laboratory systems used are discussed below, beginning with a description of the lot card system, which was found to be easy to use, efficient, and relatively problem free. Laboratory processing under each phase is then discussed in order to facilitate the use of the laboratory records by those unfamiliar with the project. Special procedures such as flotation and soil chemical testing are outlined, and finally, laboratory record keeping is described.

The Lot System

Provenience Control and Provenience Record-Keeping: The main system of provenience control and record-keeping used in the field and laboratory was the lot system developed by the University of Michigan Museum, and adapted to meet the needs of Vandenberg MX project. The primary reason for using this system was to maintain control of field and laboratory work with the least possible chance for mix-ups or mistakes.

In the lot card system a number is assigned to a specific unit of archaeological field research, e.g., a surface collected item, shovel test pit (one lot number per level), or a level of a standard excavation unit. This system provides for as much horizontal and vertical versatility as needed. The lot number follows the item or level throughout the field and laboratory

analyses. Any additional items such as soil samples, column samples, C-14 samples, etc., carry the same lot number as any other material retrieved from that specific locus.

The project had started before the introduction of the lot system, and it was necessary to evaluate that system's compatibility with the other field systems involved. Fortunately, the lot system was readily compatible with all of the earlier field or laboratory systems since the types of information collected were similar. In fact, the system was especially well suited since it was readily adaptable to changing project goals. These factors, plus the straightforwardness of the system (it is easy to learn and hard to make mistakes), convinced project personnel that this was the system to employ.

Lot Card Description: The original format of the lot card used by HDR and CCP was developed in 1980. In fall of 1981 the card was revised to contain refined information. Differences between the two cards are noted below.

Each lot card contains space to enter various types of information. The lot number is printed in the right hand corner of the lot card with a Lightning Auto Numbering Machine (i.e., no two lot cards have the same number) prior to distribution to the field. The lot number is the number used by field personnel to identify any and all materials taken from a particular locus.

Across the top of the card is space for the site number, unit number, and level number. These sections were divided into two portions on the newer cards. The lower portion of the site number space is for the field/temporary site number whereas the upper portion is for the permanent site number. The unit and level boxes are also divided into field and laboratory portions. On the earlier lot cards, additional information was written on the card next to the field entry in a different color.

On each lot card, depth is recorded in centimeters. This information is included under the "level" category on the earlier cards, but the updated cards separate "level" and "depth" categories as an added reminder that not only level number but the beginning and ending depths of STP or unit levels are important information to record. Another new addition to the lot cards is the feature number; this information was recorded under the "remarks" category on the earlier cards.

"Location" refers to provenience information such as UTM, grid number, coordinates, etc. On the earlier cards the location category was termed "grid" and "plan map". A plan map of excavation was drawn for each level, and lot number locations were recorded on the map by level. The plan map was used only at SBa-1179 and for a portion of the SBa-1718 excavations. Lot maps are similar to plan maps, and are included with each Basic Data Report (BDR). The plan map category was deleted from the updated lot cards, and unit size and screen size categories were added.

A blocked off section at the bottom of the lot card was added to the updated version. This section is for laboratory comments and for recording the number of bags of specific types of artifacts present in the laboratory

(L - lithic, B - bone, C - carbon, S - shell, M - miscellaneous materials). Providing a specific space for this information (it had been written on the lower right portion of the older cards) makes the cards neater and more legible. (Identical laboratory information is also listed on the check-in sheets.) Date, number of bags, cultural remains, remarks, and excavator categories appear on both lot card forms and are self explanatory.

The lot numbers were keyed to specific contractors as follows:

0 to 760	Materials collected by HDR in Fall of 1980.
761 to 4,558	Materials collected by CCP in Phases I and II.
6,000 to 7,887	WESTEC soil samples (these samples were never analyzed and were eventually discarded) and four artifacts collected by WESTEC.
9,000 to 9,142 and 9,200 to 9,228	Various samples (soils, artifacts, and vegetation samples) collected in connection with CCP's Sand Study Project.
14,000 to 14,227	Materials collected by HDR (and given lot numbers after CCP assumed the contract) or by COE archaeologists. (There is an exception in this category: certain materials collected by SPRI at SB-1170 were given 14,000 series numbers by mistake.)
15,000 to 15,158	Materials collected by VTN monitors. (Note: the first artifacts received by HDR from VTN, in 1980, were cataloged and do not have lot numbers.)
16,000 to 16,042	Materials collected by UCSB-OPA, but while in the CCP laboratory it was necessary to assign lot numbers to these items because they were not cataloged or (as in the case of 1,170) the materials were cataloged under one catalog number as a column sample, but for our purposes level-specific identifiers were necessary.

Field to Laboratory Procedures: Materials collected by UCSB-OPA were handled through the UCSB archaeological laboratories. Individual reports prepared by UCSB-OPA should be consulted for procedure details since various sites had different field and laboratory directors. The length of time between excavation of materials and receipt of materials by the laboratory is unknown for UCSB-OPA or early HDR.

During late HDR and all CCP phases of research, other procedures were used. Each day before entering the field a field box containing approximately 200 clean lot cards was given to the crew chief. Depending on crew size and objectives of the day, varying numbers of lot cards would be used. Bags and lot cards were collected daily at a central location, and the used and unused lot cards were returned to the laboratory every evening. Used cards were then pulled and kept in the laboratory.

Once the bags reached the laboratory they were lined up in numerical order, and the number of bags was listed on the lot cards. If a bag or lot card was missing, no further processing was done until the problem was corrected. Since this was done on a daily basis, few mistakes resulted. In the event of a missing bag or card, there was a good chance of locating it by contacting, as soon as possible, the person who dug the level (or STP, etc.). Crew members could often give information about the possible cause of a particular mix-up. Also, the daily check-in of lot cards and materials seemed to aid in careful handling of the bags from the field because each person was responsible for insuring the accuracy of his or her own lot cards and bags, and there was therefore incentive to minimize mistakes. Another responsibility of the laboratory was the development and neat appearance of the photograph and photographic records. Once film was processed the slides/photographs were checked against the photographic record for discrepancies and/or errors. Any corrections or changes were verified by the field director.

Sorting and Data Recording: Methods of sorting and data recording varied from contractor to contractor and phase to phase. Several sorting variations were used: not collecting any noncultural screen residuals, collecting selected screen residuals, collecting all screen residuals, wet screening, dry screening, use of various screen sizes (including 1/4 inch, 1/8 inch, and 1/16 inch), and other variations. On an analytical level, variations included different ways to measure the size of chipped stone items (if it was measured at all), different ways to count flakes (several size category combinations were used, and some flakes were counted by stone type), and different categories of screen residuals to be saved. Screen residuals were generally collected and sorted into artifact classes or categories. Some artifact classes were weighed, some were counted, some were measured, and some had several of the above performed. (Details of the procedures used by each contractor are given below.)

Two systems for laboratory recording were employed, the first of which was the UCSB Cataloging System. Briefly, this system breaks down collected materials from a given provenience into meaningful categories and collects various information on each item or class of items (depending on the needs and intent of the project). With the use of a computer form and an extensive code book, a cataloger has a wide range of possible categories with which to work. Once the information is coded it can be entered on computer punch cards or into a WYLBUR computer file that ultimately stores the information on a computer disk or tape. At this point, the data are easily and efficiently

manipulated. An additional asset of this system is that the information is in a concise, economically stored, and useable form, in contrast to crowded archaeological repositories containing volumes of documents. All collections catalogs resulting from work subcontracted are retained at the UCSB Department of Anthropology in computerized form.

Results of early HDR (pre-lot system) efforts were entered on UCSB coding sheets but have not been entered into the UCSB computer system. Similarly, late HDR (once the lot system was incorporated) surface materials and part of the STP materials were placed on the UCSB cataloging forms but were not entered into the computer. At HDR, STPs were not given lot numbers, and not all the STPs had been processed before the close of the HDR laboratory (all unprocessed STP materials were from SBa-1179). By the time the HDR materials had been transferred to CCP's Santa Barbara laboratory and processing began, all surface collections, STPs, and unit/levels received lot numbers. The unprocessed HDR materials were then assigned lot numbers.

Materials from SBa-1718 excavations, the result of work done by HDR and COE, were also unprocessed on their arrival to Chambers. The material from HDR's work at SBa-1718 had lot numbers, but materials from COE did not.

Even though CCP personnel used the lot system in both phases of their work on VAFB, surface materials from SBa-1193 were immediately placed on UCSB catalog forms (this information was never entered on the computer or cards) and later these items were also given lot numbers to keep all of the CCP collections consistent. It was believed originally that once specialized analyses were completed and all materials were sorted, the results would be entered on catalog sheets and bags would be given catalog numbers. Because of money and time constraints this was not accomplished.

At HDR, the lot card system was adopted primarily because research goals had not yet been concretely formulated, and therefore great quantities of time might be wasted in recording the many details on the UCSB cataloging coding sheet for items that might be discarded later or might be of little interest to the overall program to the overall program. It was more cost effective and more efficient to keep materials sorted by lot number. After the research design was completed and materials were sent to a specific analyst, he or she could readily locate specific lots containing pertinent information for research purposes and, at the same time, either catalog the materials or send them back to the HDR laboratory to be cataloged if deemed appropriate. The lot system also made it easier for different analysts to compare information. Patterns or problems would be easier to identify, since the bone, stone, etc., from a specific locus would all have the same lot number.

Each BDR contains a lot index which provides the lot number and its provenience (horizontal and vertical) plus a lot map giving the same lot information. For items that are cataloged in the UCSB system, reference to the catalog sheets is made for provenience information, and for similar information on lot numbers a reference is made to the lot index.

Packaging and Storage: Packing of samples was of concern because the potential length of time between the actual collection of a sample and its analysis was as long as two years. Small items were sorted and placed in plastic bags with the lot number written on the bag itself or on a slip of paper placed within the bag. (All UCSB-OPA artifacts were stored in this manner with the catalog number attached or inserted in the bag.) Metal (collected by CCP) was stored in coin envelopes with the appropriate information written on the envelope. The small items were then stored in small cardboard boxes by site and artifact type.

Large items such as soil samples, column samples, etc. were collected from the field in various types of plastic bags. Once the samples were processed preliminarily they were stored in strong cardboard boxes.

Lot numbers were originally written on the plastic bags, but these numbers become fainter with time, so a piece of paper with the lot number, artifact type, and count/weight was placed in the bag in an effort to avoid future identification problems.

Laboratory Processing

UCSB-OPA: Materials retrieved by different contractors were processed in different ways, as noted above. The archaeological materials collected by OPA were sorted into one of ten general artifact categories, and each item was assigned an object code corresponding to an individual entry on the USCB cataloging form. Information recorded on the forms also included provenience, count, weight, and material type.

Materials from all sites investigated by UCSB-OPA were cataloged under UCSB Department of Anthropolgy Accession No. 267, which had been assigned to OPA for MX related materials.

Early HDR: The HDR laboratory opened in September 1980. Its function was to catalog previously collected materials and to organize the Vandenberg MX project materials HDR archaeologists had been collecting from their own field reconnaissance, VTN monitors, and OPA subcontracts.

Materials were cataloged initially by HDR on the UCSB coding sheets using the UCSB Accession No. 279, assigned to HDR for MX-related materials. The soil samples were reduced to 20 g before cataloging and the rest of each sample was discarded. (It should be noted that a mechanical splitter was not used at this time; see below.)

One laboratory testing program was undertaken in this phase of work. Flakes were sifted through 1/8 inch screen, and the number of 1/8 inch or larger flakes was counted and compared to less than 1/8 inch. Some of the less than 1/8 inch flakes are slightly larger than 1/8 inch (i.e., 3/16 inch) because flakes that fell through on the diagonal were counted in the smaller category. This test was conducted to compare the ratio of greater than 1/8 inch flakes to those less than 1/8 inch within and among sites SBa-1193, SBa-1179 (prior to excavation), SBa-1180, and SBa-1181.

Late HDR: Prior to HDR's excavation of SBa-1179 in mid-October of 1980, suggestions for methods and mechanics for the excavation were solicited from personnel. At that time Kvamme suggested the use of a lot card system. Prior to this time the only source of information on the materials collected by HDR archaeologists was the field notes from excavated STPs or transit data on surface materials. This information, unfortunately, rarely reached the laboratory. The VTN materials were accompanied by a sheet listing the materials present, and UCSB-OPA materials were accompanied by the UCSB cataloging forms. Archaeological materials brought into the laboratory by HDR archaeologists were cataloged under the assumption that all the materials from the field reached the laboratory.

The lot card system was used initially in a slightly different manner than during later phases of the MX project. For example, only excavated unit/levels (or portions of levels) were given lot numbers. Surface and STP materials were directly recorded on the UCSB catalog form. Also, a field map with the grid lay-out was set up in the field for each level of excavation. As a lot card was used, the lot number was written in the appropriate grid square. In addition, each level of each unit had a floor plan map drawn. Each map included the lot number, feature information (if applicable), and the base elevations in each corner of the square.

During the excavations of SBa-1179 two column samples were taken. For one of the samples, an individual lot number was assigned to each level. The other column sample was assigned one lot number for the entire column (this was later corrected in the CCP Santa Barbara laboratory, each level being assigned its own lot number).

Screen residuals (any material left in the screen after shaking the soil through the field screens) were brought to the HDR Santa Barbara laboratory in bags where they were ordered numerically and checked against the lot cards. If a card or bag was missing out of the sequence no further laboratory work was done until the missing materials/bags were found and put into sequence.

The screen residuals of the first 58 lot numbers were immediately floated by filling a bucket with a small amount of water and the residuals, then agitating the mixture with a high pressure water spray and pouring off the lighter portion or light fraction. This process was repeated until the light fraction was separated from the heavy fraction. At this point the lot number was affixed to the light fraction, which was drying on a 1/16 inch mesh screen, and the heavy fraction was poured onto another labeled 1/16 inch mesh screen to dry. This process served two functions: 1) to separate the heavy and light fractions of the residuals (most of the artifactual materials of interest were located in the heavy fraction), and 2) to clean the artifactual materials. The fractions were then dried with the help of fans and sorted by material/artifactual type. The light fraction, with carbon and organics, sometimes took several days to dry and yielded relatively few cultural materials (only carbon). The process was therefore speeded up in a effort to keep the carbon less contaminated by impurities. Before washing the screen

residuals, each bag of residuals was poured onto a 1/16 inch mesh screen, and the carbon (and any cultural materials immediately noticed) were removed from the residuals. It was then possible to throw the light fraction away after the flotation process. Additionally, this process separated soil from the residuals, resulting in a cleaner heavy fraction after flotation.

Once the heavy fraction was dried, it was sorted according to size and material type. Items over 1/8 inch were sorted by general artifact class (e.g., lithic, bone, fire cracked rock, rock, shell, etc.) Shell fragments 1/8 inch or larger in size were sorted to species. In the beginning, smaller fragments were also sorted to species when possible, but this was too difficult and time consuming to continue. (While identifying Mytilus shell valves from Feature 1 at SBa-1179, they were also counted for use by the shell analyst at a later time.) The sample of items smaller than 1/8 inch was checked quickly for recognizable artifacts and then the remainder (mostly shell) was bagged and marked "less than 1/8 inch."

Once sorted, materials were boxed by lot number for possible future analysis. Soil samples were boxed without drying. Carbon samples were weighed and entered on the UCSB cataloging sheets under Accession No. 279. (Carbon was handled differently during the HDR phase of the MX contract. Some of the carbon samples were washed in the screen residuals in the laboratory, some of them were sorted out of the residuals before flotation, some of the samples were stored in plastic bags, and some were stored in aluminum foil, based on different recommendations from various people. These variations in procedures are noted on the lot card.) All samples are stored in aluminum foil at the present time.

After all the materials within the heavy fraction were separated, the number of bags present for each artifact class was noted on the lot card as a check. This was a final control over what materials were present in the laboratory.

It should be noted that not all materials collected by HDR were processed before the closing of the HDR laboratory in December 1980. At that date, STP materials from SBa-1179 and materials from SBa-1718 had not been processed, and nothing further was done until the materials were transferred to CCP's Santa Barbara laboratory in spring of 1981. At that time the materials from the December 1980 COE excavations at SBa-1718 were added to the materials in need of processing.

CCP Phase I: When CCP was awarded the contract in January 1981 to continue the work begun by HDR, testing began immediately at SBa-1193. Changes to the lot system were made to create a more comprehensive system. The main change in the laboratory was the addition of a check-in sheet to facilitate record-keeping for various sites during rapid field excavations. This sheet shows which lot cards were used and with which sites the lot cards are associated. The check-in sheet includes columns for the lot number, the number of soil samples taken in the field, and information on the soil sample's storage status, nature of screen residuals (gravel, organics, lithics, carbon), comments, and a space for the number of bags of each

artifact type in the laboratory (this last item was filled in after the processing of the screen residuals). The site number was, of course, also noted.

Although HDR did not give STPs lot numbers, CCP personnel decided that to best utilize the lot system each level of each STP should also be assigned a lot number.

Once materials were brought into the laboratory, they were placed in numerical order and checked in to make sure all were accounted for. The soil samples were then separated from the screen residuals and boxed by site in numerical order. (Soil samples were not dried prior to storage.)

The next step was basically the same as done by HDR (see previous section for details); only differences in the procedures are discussed here. Since excavated deposits from certain sites (SBa-1193 and -1174) were water screened, the examination of the residuals for carbon before the flotation was unnecessary, and sorting of carbon was done only when the residuals had been dry screened in the field. CCP also initiated noting the presence of carbon in the residuals (or in the field) in insufficient quantity to be collected (HDR and CCP collected pea size or larger pieces, or multiple smaller pieces of carbon). This information was listed on the lot card and check-in sheet.

Once again the problem with the light fraction was addressed. Carbon was being collected before the flotation, and the only material of possible interest remaining in the light fraction was very fine flakes trapped in the organic mat. A test was conducted using ten samples, some known to have cultural materials present and some thought to be sterile. Once processed, the light fraction of these test samples was dried and carefully sorted. It was found that the flotation technique was successful, i.e., no cultural materials were found in the light fraction. Therefore, because of time and space limitations and evidence that cultural materials were not present in the light fraction, it was decided to discard the light fraction as had been done by HDR. Once the heavy fraction had dried (which usually took overnight) bone, shell, lithics, historic materials, etc. were sorted from the heavy fraction with the aid of an illuminated magnifying glass (this had not been used at HDR). The materials were bagged by artifact class with materials pulled before the flotation process, when applicable. Another addition made by the CCP laboratory was the separation of lithics into four categories: micro (less than 2 mm), small (2 mm to 5 mm), medium (5 mm to 10 mm), and large (over 10 mm). These categories were arbitrarily chosen. Measurements were performed by placing the flake on a sheet of paper with the appropriate size categories carefully drawn on it. The maximum length of the flakes was then measured. The number of flakes (including the number in each size category) and presence of any other cultural items were entered onto a rough result sheet, and the number of bags was recorded on the check-in sheet and on the lot cards. This completed the primary cycle of laboratory procedures used in the CCP Phase I field laboratory in Lompoc, California.

The result sheets were in a very general format since it was unclear what information would be of interest to the later analysis. Surface collected materials were immediately recorded on UCSB catalog forms (for SBa-1193) under Accession No. 279. For STPs, a list was made which included co-ordinates and/or STP number in numerical order, level of occurrence, the corresponding lot number, a list of materials present, and the lithic breakdown. Each unit had its own sheet with the unit number at the top.

It should be noted also that even though the field work did not employ the use of plan maps, the laboratory created these maps on a daily basis to keep up with progress at certain sites (especially those at which many STPs were being placed) and to detect errors before they would be irreversible. This was especially important at SBa-1193.

CCP Phase II: This phase of research by CCP began with the award of a new contract to CCP (see Project History in Chapter 1). Once the research design was finished, the need for certain changes in the compilation of appropriate information for analysis was apparent. The main procedural change was in the result sheets and the lot cards.

The check-in of materials from the field was similar to that in Phase I except that surface collected items were now also assigned lot numbers rather than being cataloged. This was done for better control over all of the materials.

Sorting of the screen residuals was accomplished by one of three methods, depending on the makeup of the soil:

1. Residuals with high organic content and small or no amounts of shale were processed as in Phase I.

2. Residuals with high shale content or many large rocks were poured onto screen of 1 inch mesh with 1/2 inch, 1/4 inch, 1/8 inch screens stacked underneath (1/16 inch mesh was inserted for materials which had been screened in the field to 1/16 inch). The cultural materials were then extracted from each of the screens and combined by artifact class for each lot number. (This process was necessary due to problems with damp shale and the large quantities of screen residuals in these soils which made identification of cultural items difficult.) This system was not useable in situations of high organic residuals because the organics become caught in the screens and there was difficulty in agitating adequately this type of sample.

3. Residuals with very high sand content, small amounts of organics, and minimal residuals of any kind. These were placed on a tray and sorted by artifact type. This was fairly easy since most of the materials present were cultural.

Once the cultural materials were sorted they were bagged by artifact class with the lot number, count, and/or weight of the item printed on the bag. Shell and carbon were weighed; bone, historic materials, undifferentiated lithics, fire affected rock, ground stone, and concretions were counted and weighed; chipped stone tools were counted (and in some cases dimensions measured); chipped stone debitage was counted according to the size breakdown in categories of 1/16 inch, 1/8 inch, 1/4 inch, and 1/2 inch or larger. These size categories refer to the screen size the flakes could no longer pass through, and the actual minimum size for each category is actually larger because flakes could pass through the screens on the diagonal of the mesh square.

The result sheets were designed to collect information necessary for the research goals in a neat, easily readable fashion. (The result sheets are included in the BDR for each site.) In addition to recording information on collected materials, the result sheets indicate whether the lot number/materials are from an STP or unit level, and provide provenience information and additional comments made in the laboratory.

The materials were sorted by site, artifact type, and lot number. Information on the number of bags was once again placed on the check-in sheets and lot card as a final control.

Soil samples were collected slightly differently during the second phase of work. These soil samples were dried before storing, sometimes with a heat lamp. Since the samples were open to the air for up to a week, they probably would not be of use for pollen analysis.

In both phases of CCP's work, soil samples were taken from inside the actual STP or unit. However, column and flotation samples were taken from outside of the 1 x 1 m units, yet have the same lot number as materials within the square. This inconsistency was not addressed until fairly late in the project, and resulted in a slight difference in the total volume of excavated soil for each site.

Closing of the Field Laboratory and Goals of the Santa Barbara Laboratory

Once the field work ended at VAFB (late fall 1981), the items collected by CCP during the year were checked to insure no materials had been lost, and they were then packed for transport to the Santa Barbara Laboratory. Upon arriving at the Santa Barbara Laboratory, the materials were entered into the Control Book, which acted as a record or receipt to date and verify everything entering the laboratory. The details of this system are explained below under Laboratory Record-Keeping.

Once the Santa Barbara laboratory was opened, the first item of business was the "catch-up" need of the collections, including processing the materials from HDR and COE investigations which had not been previously processed in the HDR laboratory. Completion of various catch-up tasks was necessary to prepare the collections for analysis.

The materials were processed in the same manner as was done at HDR using some of the same personnel. It was also necessary to check through the less-than-1/8 inch portions of each lot from the SBa-1179 excavations to separate this material by artifact type. Another item of business was the resizing of all lithics collected by UCSB-OPA, HDR, CCP Phase I, and VTN into the size categories used for CCP Phase II as requested by the lithic analyst. VTN materials were incorporated into the system by assigning lot numbers in the 15,000 series and making appropriate entries on check-in sheets and results sheets. Appropriate site numbers were referenced when possible. Materials were labeled (by site) in one of three ways. Depending on location, the materials were 1) given a site number, 2) given a site number "VICINITY" (this meant that the material was near but probably not within the known boundaries of the site), 3) given a site number "AREA" (this indicated that no clear boundaries had been determined for the site, so there was no way of knowing if the materials were within the boundaries of the site or not). Some materials were clearly isolates, and this information is noted on the lot index and result sheets.

To incorporate the materials by site, VTN's field maps and CCP's lot numbers were correlated with the appropriate field numbers given by VTN; these locations were then compared to known site maps. There were some problems in making correlations due to differential labeling and incompatibility of field maps, but most of the artifacts have fairly precise locations.

Another catch-up task was to enter the results of HDR's SBa-1179 excavations onto CCP's result sheets. The result sheets were adapted slightly, and the number of bags was entered instead of the number of items present. Result sheets were made for various other materials which were collected by other contractors, but had not been given catalog or lot numbers, e.g., for various noncultural items collected by UCSB-OPA (from SBa-1170) but never entered on catalog coding sheets. CCP assigned lot numbers to those items and then entered the data on result sheets.

In rare cases, items with UCSB catalog numbers were also assigned lot numbers. An example is the surface items from SBa-1193 (for continuity) and column samples from SBa-1176 (the column samples had to be broken into more refined subdivisions before processing could begin). However, lot numbers were not assigned to the unsorted materials from SBa-1036; they were sorted and entered on the result sheets under the appropriate catalog number. (There was no need to assign lot numbers in this case since each catalog number acted as a lot number in identifying the material from a given level.) CCP also assigned lot numbers to SBa-1036 column samples, but later realized it had not been necessary.

All soil testing and the column and flotation sample processing was done in the Santa Barbara laboratory. The processing of soil samples was done under guidance from geologist Thomas Rockwell. The soil samples were first passed through a geological soil splitter to ensure that a representative

portion of each sample was obtained for analysis. This was especially important since some of the samples had been in storage for over one year and settling of the sediments could be a problem when obtaining small portions from large bags of collected soils.

Selection of soil samples for analysis depended on the amounts of cultural materials (such as shell, bone and chipped stone) present, soil changes observed in profiles during field work, and the presumption that the soil was not in a disturbed context. (See flotation procedures for details concerning minimum amounts of artifactual material necessary, importance of soil changes, and how disturbed areas were defined.) Certain kinds of data could not be collected if the sample size was too small. For example, if a soil sample weighed only 50 g, neither a column/sieve nor a flotation sample could be processed, but with as little as 20 g of soil present it was possible to run chemical soil tests of interest. The soil, column/sieve, and flotation samples were first screened through 2 mm screen mesh to remove large items which might clog the mechanical splitting device. Primary screening was achieved by one of two methods, depending on the size of the sample. If the sample was small, an 8 inch diameter, 2 mm sieve and pan were held together and the soil was poured through the sieve. For large samples, an 8 inch diameter sieve of 2 mm mesh was mounted over a hole in a piece of cardboard covered with aluminum foil (the foil was necessary for easy cleaning and to minimize contamination between samples). The cardboard and the sieve were then placed over a clean 5 gallon bucket, and the larger samples were sifted through the sieve into the bucket. Any materials greater than 2 mm in size were then extracted from the sample and recorded on a column/sieve or flotation analysis form by count and weight, presence or absence of materials in the 2 mm or larger sized materials. It was poured through the splitting device which divided the sample into relatively equal portions. This process was repeated until the desired amount of soil remained. For soil testing, two 50 g portions were extracted. Once the samples were extracted, the actual processing of the materials began.

For ease and uniform collection of data, a set of coding sheets were developed to record pertinent information on each sample to be processed. These sheets are briefly discussed below.

Special Procedures

The various preparations and soil tests were coded on a special set of coding sheets. Briefly, Coding Sheet I was designed to record general information on the sample including the type of sample, weight, location, etc. Coding Sheet II was designed to record specific information (or results) of the Chemical Soil Testing program. A detailed explanation of the coding forms and their use is incorporated in individual BDRs (when applicable) and at the project archive at UCSB.

Soil Testing Program: Because of our inexperience with the procedures, this study was conducted with many consultations with geologist Rockwell, who demonstrated the use of a La Motte Combination Soil Testing Outfit

(Model STH Series) and instructed the laboratory crew on the testing procedures. La Motte's instruction manual was followed in conducting the soil tests. The tests used initially were for particle size, pH, phosphorus, calcium, manganese, humus, iron, calcium carbonate, and Munsell soil color. Of these tests, only those for particle size, pH, phosphorus, calcium, and soil color were retained for the soils analysis presented in Chapter 6. The manganese test was designed as an aid to separating dark midden soils from soils darkened as a result of the presence of manganese particles. Since initial results indicated that the test solution was apparently not strong enough to break down the manganese present in the dune soils, the test was abandoned. The humus test, which was thought to indicate the presence of organics in midden soils, gave anomalously high values and was therefore abandoned as well. The iron test was eliminated because it failed to identify high proporations of iron in a plynthite (ironstone concentration), perhaps due to the inability of the sulfamic acid used in the test to break down iron (LaVern Hoffman, personal communication). Finally, the calcium carbonate test as dropped due to the high cost of instrumentation necessary for making readings of sufficient sensitivity.

Once the meaningful tests were determined, the soil testing program ran smoothly. The results were placed on Fortran coding forms and Mechanical and Chemical Soil Testing Inventory forms for easy and visual inspection. At the same time, a list of lots, results of soil tests, cultural materials present, and a profile were made for each test unit in order that an easy visual impression of the results was possible.

Sieving and Column Samples: Samples were chosen for analysis of soil chemistry and midden constituents if they were 1) important to an understanding of site and age of the dune deposits, 2) from areas with large amounts of cultural materials, 3) from areas with vertical differences in amounts of cultural materials.

After consultation with J. Serena, the shellfish remains analyst, and M. Glassow, the principal investigator, it was decided that a 300 g sample would be sufficient for our needs from both the geological and archaeological perspectives. The samples were first split to obtain a representative portion of the total sample. Three hundred grams were removed and placed in a box lined with aluminum foil in order that fine materials would not adhere to the cardboard box. The box was then covered with foil and the lot number placed on it. See Chapter 6 for details of the process of passing the soil samples through a series of sieves. The contents of each sieve were weighed and the weight was recorded on the sieve/column forms (this form was also used to record the information on materials collected during the 2 mm sieving and the presence of cultural material in the 10 or 18 sieves). The Nos. 10 and 18 sieve residuals were not immediately checked for cultural materials, but this was done later. The No. 10 and/or No. 18 sieve residuals were kept in vials labelled with the lot number and the size of the screen from which the residuals came. If there were residual materials in the No. 10 or 18 sieve, they were quickly examined, and if no cultural materials were found,

"in bulk" was written next to the appropriate screen size of the Sieve/Column Result Sheet and the soil was thrown in with the bulk materials (this consisted of the No. 35, 60, and 120 sieve soil after each was weighed separately). The No. 230 sieve residuals were bagged separately because this sieve size appeared to collect the heavy minerals in the soils (note: if any one sieve's residuals had a drastically different color from the others within the sample, the varying portion stored separately). The pan residuals were also bagged separately for later use by geologists T. Rockwell or D. Johnson in determining the silt and clay content of the soils.

After a sample's residuals were weighed, the weights were totaled to quantify any material loss during the sieving. If a sample's post-sieving weight was less than 98 percent of the original starting weight, the sample was not used for further analysis.

A 300 g sample was used as the starting weight for column/sieves because it maximized the capabilities of the sieves and the shaker. Too large a sample of soil would not sieve as accurately, yet chosen weight was enough to get an idea of what types of cultural materials were within the sample. The actual weights were usually not exactly 300 g because of minor vagaries in the weighing process.

Once sieving was well underway, Rockwell noticed that certain dark samples seemed to have fine particles adhering to the sand grains. To alleviate this problem he had the laboratory personnel grind the samples (first removing the 1 mm and 2 mm cultural materials) and then rub the soils around on a piece of freezer paper before sieving. This helped, but not as much as Rockwell had hoped. At this point he believed it was necessary to bleach a few samples to see how much material was sticking to the sand grains. The first bleaching procedure involved submerging the samples in peroxide, cooking the mixture for 10 minutes, and letting it stand overnight. This did not obtain the desired results, so household bleach (Clorox) was used in place of peroxide. The use of household bleach gained the desirable result, but the procedure was time and area consuming. First, the sample was sieved, then the "bulk" materials were submerged in Clorox, allowed to stand overnight, then poured through a No. 230 sieve, rinsed repeatedly with water, and finally dried for three to five days. Then the sieving process was repeated so that the weights of the bleached and unbleached portions could be compared. Since only the 35, 60, and 120 "bulk" was bleached, this meant that there were two distinctly different looking No. 230 sieve and pan portions from each sample. Only some of the soil samples from SBa-706 were bleached.

Flotation: Twenty-four samples were floated in order to obtain samples of carbonized material. Sites represented are SBa-706, -980, -1036, -1070, -1070E, -1176, -1179, -1193, -1718.

Since only a small number of flotation samples could be processed, it was important to choose productive samples. To accomplish this, a graph for each unit was made, showing for each level and lot number the pH, phosphorus,

and calcium test results, and the amount (count or weight) of shell, lithics, bone, and fire affected rock. The profile of each unit was drawn. The abundance of each of the four categories of cultural material was then used to produce four rankings of the levels, the level with the highest abundance receiving the lowest rank. In case of levels with equal amounts of a particular item, the levels were both assigned the same rank. Once the level with the lowest rank sum was determined, the soil test results were consulted to ascertain which level or levels were associated with which reading in each of the soil tests. A level sample was selected for flotation if it was associated with a low rank sum and high soils test readings. This was then checked against the profile to be sure that the sample was not from the surface or a contaminated level (e.g., road fill, rodent disturbance).

The flotation samples were first weighed. The weights varied from sample to sample depending on how much soil had been used in soil and column/sieve test. In the case of SBa-1070E, however, the flotation samples were collected as such in the field, and the sample was then dissolved in a small amount of water. To the mixture was added more water with a spray nozzle, which agitated the sample such that as much material as possible was dissolved and suspended in a slurry. The slurry was then poured through a Nos. 10, 18, and 35 sieve stack. Water was added until all suspended materials had been poured off. Each screen was then emptied onto newsprint to dry, with the lot number and screen size written on the newsprint. The contents of each of the sieves was then separated by artifact class (e.g., carbon, lithics, shell, seeds, and/or historic materials).

There was one change instituted while flotation was underway (after two samples had been processed). The change consisted of rinsing the remaining heavy materials through a No. 18 sieve. The materials caught in the No. 18 sieve were kept and marked "18 heavy." Much of the shell and lithics appeared in this portion. One last step was taken: after the process was finished, a film cannister full of the remaining sludge was retrieved for later inspection (if necessary). This last sample was stored wet and has not been inspected.

The Nos. 10, 18, and 18 heavy sieve samples were sorted, but the No. 35 sieve sample was not owing to the excessively small size of the items it might contain.

<u>Seed Analysis Procedures</u>: During the 2 mm split and flotation procedures, seeds were sorted from the various sized sieves and bagged according to lot number and screen size. Once the seeds were separated out, they were sent to botonist MaryAnn Christensen. She confirmed that they were indeed seeds and determined whether or not they were carbonized. For archaeological purposes, carbonized seeds are possibly the result of prehistoric activities at sites, whereas uncarbonized seeds are assumed to survive only several years and are therefore the result of natural deposition. Given the likelihood of naturally caused fires during the course of prehistory, many carbonized seeds may also be the result of natural deposition.

The extremely low density of carbonized seeds (seven total), their poor condition (making it difficult to identify past family membership), and the questionable relationship of these seeds to the prehistoric materials meant that no further analysis was justifed. Their proveniences were therefore simply recorded on the Flotation form and Size Analysis by Sieving sheets and on the lot cards.

Laboratory Record-Keeping

A "control" book was kept in the Santa Barbara laboratory. Within this book is a list of sequential numbers pertaining to manuscripts, boxes of artifacts, etc., which entered the laboratory. Next to each number is a space to describe what was entering the laboratory (e.g., title and author of a manuscript), quantity, project, date, and recorder. This information was recorded for better control over what materials were in the laboratory and when they entered the laboratory.

Additional specially designed sheets were kept in the back of the control book. These were for recording more specific information about artifacts entering the laboratory. These sheets contained the control number, State site number, type of sample, lot number, UCSB catalog number, number of boxes, date sample was sent for analysis, and the date the sample or results of the analysis were received.

For manuscripts, bibliographic index cards were kept. The cards include the year, author, and title of the text on the front of the cards and a list of sites referred to in the text on the reverse side. This card file was helpful in locating texts pertaining to a specific site. The check-in sheets from the field laboratory were transferred with the collection to the Santa Barbara laboratory. For items given lot numbers in Santa Barbara, check-in sheets were completed.

All the lot cards are currently housed in the Santa Barbara laboratory and sorted by site and lot number. These cards have been used frequently to check for errors or to clear up discrepancies.

Document files have been kept by site when possible and divided into "active" sites, or sites at which work was then in progress and sites for which data files exist but at which no work was then in progress. The second set of files includes manuscripts organized by year. This is further broken down into management versus manuscripts containing information on multiple sites.

Lastly, the project staff has produced Basic Data Reports (BDRs), which include all pertinent data on sites which have sustained some sort of impact (even if only archaeological) during the MX construction. These reports include all relevant lot numbers, catalog numbers, accession numbers, descriptions and results of field and laboratory work, maps and any other material on the site available at the time they were compiled in 1982. The BDRs incorporate work done by UCSB-OPA, HDR, CCP, and VTN.

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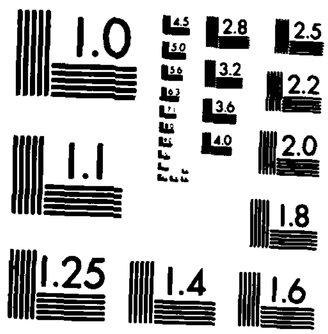

˜OPY RESOLUTION TEST CHART

A condensed site vita for each site on the San Antonio Terrace complements the BDRs. These vitae are contained in the Master Chart (compiled and written primarily by Sheila Callison), which not only gives information on sites sustaining damage but all information available on all sites on the San Antonio Terrace.

In conclusion, the laboratory procedures discussed above evolved as research problems became more focused and as the nature of the archaeological data became better understood. The end product was a system for generating, recording, and managing the data base which was both workable and adaptable to varying circumstances. The objective of the system was to prepare and produce data not only for this project's analysis but for easy access and effective use by future researchers.

SITE AND AREA SPECIFIC DESCRIPTIONS

This section is organized according to the various facilities associated with the MX missile project.

12.47 KV Power Line Corridor

The 12.47 KV power line designed to provide the major power source for the MX Missile System Installations extends north from the ICF to the various facilities, shelters and test pads located throughout the San Antonio Terrace dunelands. Generally, the powerline route was designed to run parallel to existing roads with short access spurs leading to the facilities. The proposed route was initially surveyed by HDR archaeologists in 1979 during initial planning studies for the MX project. Zigzag transects were employed to cover a survey corridor 20 m wide. The access spurs were not surveyed. HDR's preliminary survey identified six previously recorded archaeological sites (SBa-592, -953, -594, -595, -1037, and -1060) within the potential impact areas. SBa-592 was subsequently tested by UCSB-OPA as part of a fuels management program (Neff 1982).

Design changes made in May 1980 removed SBa-594 from the area of probable impact. HDR archaeologists surveyed the revised 12.47 KV powerline route and its facility access spurs during summer 1980. Using existing utility poles as the centerline, a 30 m corridor was examined in zigzag transects. Six additional sites (SBa-704, -998, -1059, -1172, -1173, and -1565) were identified along the revised powerline route.

Site descriptions and a discussion of any testing carried out by HDR on these resources are provided below. Sites that were impacted by other MX-related projects and/or involved additional investigation by CCP (SBa-704, -998, -1172, and -1173) are discussed in later sections of this chapter.

SBa-592

Immediate Environmental Context: The site is located south of San Antonio Creek at the north edge of Burton Mesa on the west terrace of a tributary drainage to San Antonio Creek. Soils are brown, hard-packed, silty sand with concretions. Vegetation is coastal sage scrub.

Gross Site Characteristics: SBa-592 is a highly disturbed ephemeral lithic surface deposit. In addition to several non-local cobbles, five chert flakes and two fragments of chert shatter were noted over an area of approximately 1200 m^2. An existing power line passes through the site.

Nature of the Investigations: HDR excavated four STPs at the location of the power poles and their guy wire anchors. Materials noted on the surface were not collected and the four STPs, excavated to depths ranging from 40 cm to 80 cm, were devoid of cultural material. HDR estimated from surface examination that previous blading had destroyed approximately 75 percent of this site.

SBa-593

Immediate Environmental Context: The site is located at the leading edge of the intermediate dunes in loose sand on a tongue of land bounded to the east and west by deep seasonal drainages. The predominant vegetation is coastal sage scrub with willow present in both drainages.

Gross Site Characteristics: The site consists of a light scatter of lithic flakes and shatter, along with a single broken projectile point. Based upon surface examination, the site is estimated to measure 120 m x 160 m; the depth of the deposit is unknown. A road cuts through the northern portion of the site.

Nature of the Investigations: HDR's survey crew noted in 1979 that heavy vegetation obscured surface visibility. SBa-593 was not surface collected, nor was subsurface testing undertaken at the site. Power pole emplacement was monitored by VTN archaeologists; no archaeological material was recovered during the monitoring operation. VTN monitors noted a lithic scatter to the east of the site outside of the 12.47 KV construction area. As mapped by VTN, the lithic scatter is bounded on the west by the east bounding drainage adjacent to SBa-593. The deposit was not recorded as an archaeological site.

Additional work is needed to define the boundaries and complexity of SBa-593.

SBa-594

Immediate Environmental Context: The site rests on an intermediate dune ridge bisected by a road. The dune swale immediately east of the site contains a fresh water pond. Site vegetation consists of coastal sage scrub and ice plant.

Gross Site Characteristics: Based on surface survey, the deposit measures an estimated 60 m x 120 m. It consists of a light scatter of several flakes, a single cracked rock fragment and a small amount of shell. The

vertical dimensions of the site are unknown. The eastern portion of SBa-594 has been disturbed by extensive bulldozing, and a buried cable line has impacted the western portion of the site.

Nature of the Investigations: Project redesign removed SBa-594 from the 12.47 KV area of possible impact. CCP obtained a pollen sample from the west edge of the pond forming the east boundary of the site. WESTEC surveyed zigzag transects within a 15 m wide corridor, and encountered the site on survey corridor V-F during their 1981 field investigations prior to seismic testing by the Union Oil Company. The site was avoided by the seismic testing operation. No subsurface testing or surface collection was undertaken at this site by either HDR or WESTEC.

SBa-595 and SBa-1060

Immediate Environmental Context: Both sites are situated in the southern portion of the San Antonio Terrace. SBa-1060 was recorded by L. Spanne in 1973, and SBa-595 was recorded by HDR archaeologists during the planning phase of the 12.47 KV power line survey. Since the deposits are contiguous they will be treated here as one site. The sites are deposited on old dune soils stabilized by coastal sage scrub vegetation. A large wetland is located 60 m south of the site.

Gross Site Characteristics: Based on surface inspection, this is a large deposit measuring approximately 800 m north-south and 500 m east-west. The depth of the deposit is not known. A wide variety of materials have been reported from the surface of the site, including shell, fire altered rock, chipped stone debitage and bifaces. HDR archaeologists noted a dense concentration of artifacts in a possible midden context in the southern portion of SBa-595. According to HDR, SBa-595 and -1060 appear to represent separate occupations. Spanne describes SBa-1060 as a light to moderate surface density of chipping detritus with some shell present. He also notes several projectile points, tarring pebbles, and a spire ground whole *Olivella* sp. shell bead.

Nature of the Investigations: No subsurface investigations were undertaken at SBa-595, nor was the site surface collected. The 12.47 KV line power pole emplacements through the southern portion of SBa-1060 were monitored by VTN archaeologists. Several nonutilized chert flakes were noted but not collected. In conjunction with construction of a temporary power line extending from the 12.47 KV line to the MMF, HDR excavated 6 STPs, ranging in depth from about 10 m to about 120 cm, at pole emplacement locations across the central portion of SBa-1060. Only two bone fragments were recovered. Soil samples were obtained from five of the STPs. The site was not surface collected by HDR; Spanne, however, surface collected diagnostic material (including the bead mentioned above) in 1973. This site was also encountered along survey line VH by WESTEC archaeologists prior to Union Oil Company's seismic testing program. WESTEC's investigation consisted of a surface inspection following zigzag transects within a 15 m corridor.

SBa-1037 and SBa-1565

Immediate Environmental Context: These refer respectively to the west and east portions of a single deposit artificially separated by a road. As originally recorded by Spanne in 1972, SBa-1037 encompasses the western portion of SBa-1565 as recorded by HDR in 1979. The site is located on a subdued old dune surface. Soils are well-developed and very sandy. Vegetation consists of coastal sage scrub and exotic grasses. The San Antonio Creek drainage is just to the south of both sites, and an unnamed lake forms the easternmost boundary of SBa-1037.

Gross Site Characteristics: Together, the sites measure approximately 500 m north-south and 350 m east-west and form a complex deposit of midden areas, depressions, and shell lithic scatters. Limited STP testing at 12.47 KV power pole emplacement locations at SBa-1037 indicate that cultural material extend to a depth of at least 1 m. Both sites have sustained previous impacts from road constructions and a buried cable line that crosses SBa-1565.

Nature of the Investigations: In addition to the 12.47 KV powerline pole emplacements, proposed impacts to the site included widening of a road and use of a borrow area on the east side that road. As a consequence of these additional planned impacts, HDR archaeologists expanded their survey corridor to 30 m on either side of the existing roads, and to selected landforms that were inspected to 60 m from the road margins. The proposed borrow area, encompassing approximately 102,000 m^2 was surveyed in 15 m to 20 m transect intervals. The borrow area was subsequently rejected to avoid impacting SBa-1565, which was located and recorded as the result of this survey.

Limited STP testing was undertaken at proposed 12.47 KV pole emplacement locations through both sites. Under contract to HDR, UCSB-OPA (Arnold 1980) excavated four STPs (ranging in depth from 5 cm to 100 cm) in SBa-1037 during May and June 1980. Cultural materials including chipped stone flakes, shell, and bone were recovered to depths of at least 1 m. A controlled surface collection was also made of an area 7 m wide and extending 770 m along the proposed power pole alignment. A single biface blade fragment was collected from site SBa-1037 by Spanne in 1972. Power pole installations were monitored by VTN archaeologists in October 1980, and additional materials were recovered from the site surface at that time.

In December 1980 HDR archaeologists excavated four STPs (ranging in depth from 80 cm to 100 cm) at proposed 12.47 KV power pole locations in SBa-1565. Ten chipped stone flakes were recovered from HDR's STPs. The site was not surface collected.

SBa-1059

Immediate Environmental Context: The site is located on a dune knoll of intermediate age to the west of SBa-1060. Site vegetation consists of coastal sage scrub.

Gross Site Characteristics: Horizontally the deposit measures 50 m x 75 m and consists of a light scatter of shell and chipping waste; the vertical dimensions of the site have not been determined. Several whole Olivella sp. beads were observed on the surface by HDR archaeologists. Previous sustained impacts include a jeep trail at the southern margin of the site, and eucalyptus trees planted across the southern half.

Nature of Investigations: The site was originally recorded by Spanne during UCSB's 1971 survey of VAFB; the boundaries were enlarged as a result of HDR's 1980 12.47 KV line survey. HDR excavated three STPs, ranging in depth from approximately 10 cm to about 120 cm, at the proposed pole emplacement locations for a temporary power line extending from the 12.47 KV line on a road to the MMF. The result of HDR's limited testing were negative; however, the 12.47 KV line passed through the periphery of the site. Pole emplacements were monitored by VTN archaeologists, again with negative results. The site was not surface collected. HDR archaeologists suggest that SBa-1059 could be an extension of SBa-1060.

MMF and ICF

The MMF and ICF siting locations are located in the southern portion of the San Antonio Terrace in close proximity to several large complex prehistoric deposits with poorly defined boundaries. The areas of potential impact were surveyed in zigzag transects at 20 m intervals by HDR archaeologists in 1979. The result of HDR's surface inspection were negative and the areas were cleared for construction. HDR did note that heavy ground cover precluded a complete visual inspection of the ground surface in some areas of the impact zone. The construction of both facilities was monitored by VTN archaeologists during the summer and fall of 1980.

Several isolated finds were recovered during construction monitoring of the ICF. In addition to fossil whale bone (which was analyzed by Dr. Robert S. Gray of the Department of Earth and Planetary Science, Santa Barbara City College), one chert flake and one Haliotis sp. shell fragment were collected from the ICF. A Monterey chert biface fragment was recovered during the blading of the ICF access road.

VTN monitors recovered several artifacts during the construction monitoring of the MMF. Although not designated a site by VTN, the locations of the artifacts, as mapped, indicated a specific locus and the site was subsequently recorded by CCP as SBa-1777. A complete description of the site is provided below.

SBa-1777

Immediate Environmental Context: The site is located on old dune soils just southeast of the leading edge of the intermediate dunes. Vegetation is generally heavy and consists of coastal sage scrub and introduced grasses.

Gross Site Characteristics: Because of the extreme disturbance and concomitant artifact displacement caused by construction grading, the site boundaries were mapped coterminous with the limits of construction. Horizontally, the area measures 106 m x 288 m. As controlled testing was not implemented prior to construction, the vertical dimensions are unknown. The site was likely destroyed by the construction of the MMF; however, intact deposits may be present beyond the limits of construction. Artifacts recovered by VTN monitors include chipped stone debitage, six chipped stone tools, and one hammerstone. In addition, several fragments of mammal bone were recovered, and shell was also noted but apparently not collected.

Description of Investigation: HDR's field reconnaissance and VTN's construction monitoring, both of which are described above, are the only investigations that were carried out at SBa-1777. Additional survey undertaken by CCP in the vicinity of SBa-1777 is documented below.

MMF and ICF Parking Lot Surveys (Figure 3-1)

In August 1981 CCP conducted both surface and subsurface surveys on two proposed parking lots (a primary and a secondary facility) to be sited between the MMF and the ICF. Both lots were within the area previously surveyed by HDR, but because of the archaeological deposit discovered at the MMF (SBa-1777) and the isolated finds recovered from the ICF, CCP was directed by the COE to resurvey the area using close interval transects and subsurface survey.

CCP archaeologists surface inspected both impact areas in 3 m transect intervals. Surface visibility was limited by vegetation. No cultural materials were observed during the visual inspections of the two parking lots.

Subsurface survey entailed the excavated of 51 STPs at 10 m intervals within the two parking areas (34 in the primary parking facility and 17 in the secondary parking facility). Each STP measured approximately 30 cm x 30 cm and was excavated in a single level to 50 cm. No cultural remains were recovered from the secondary parking lot. A fragment of burned mammal bone (possibly sea mammal) and a spent modern bullet were the only cultural materials recovered from the primary parking facility.

69 KV Power Line Corridor Survey

The 69 KV power line was designed to carry overhead power transmission lines from Substation A, located on Burton Mesa south of San Antonio Creek near Lompoc-Casmalia Road, north to Substation E, situated south of Bishop Road. The power line extends for a distance of approximately 8 km

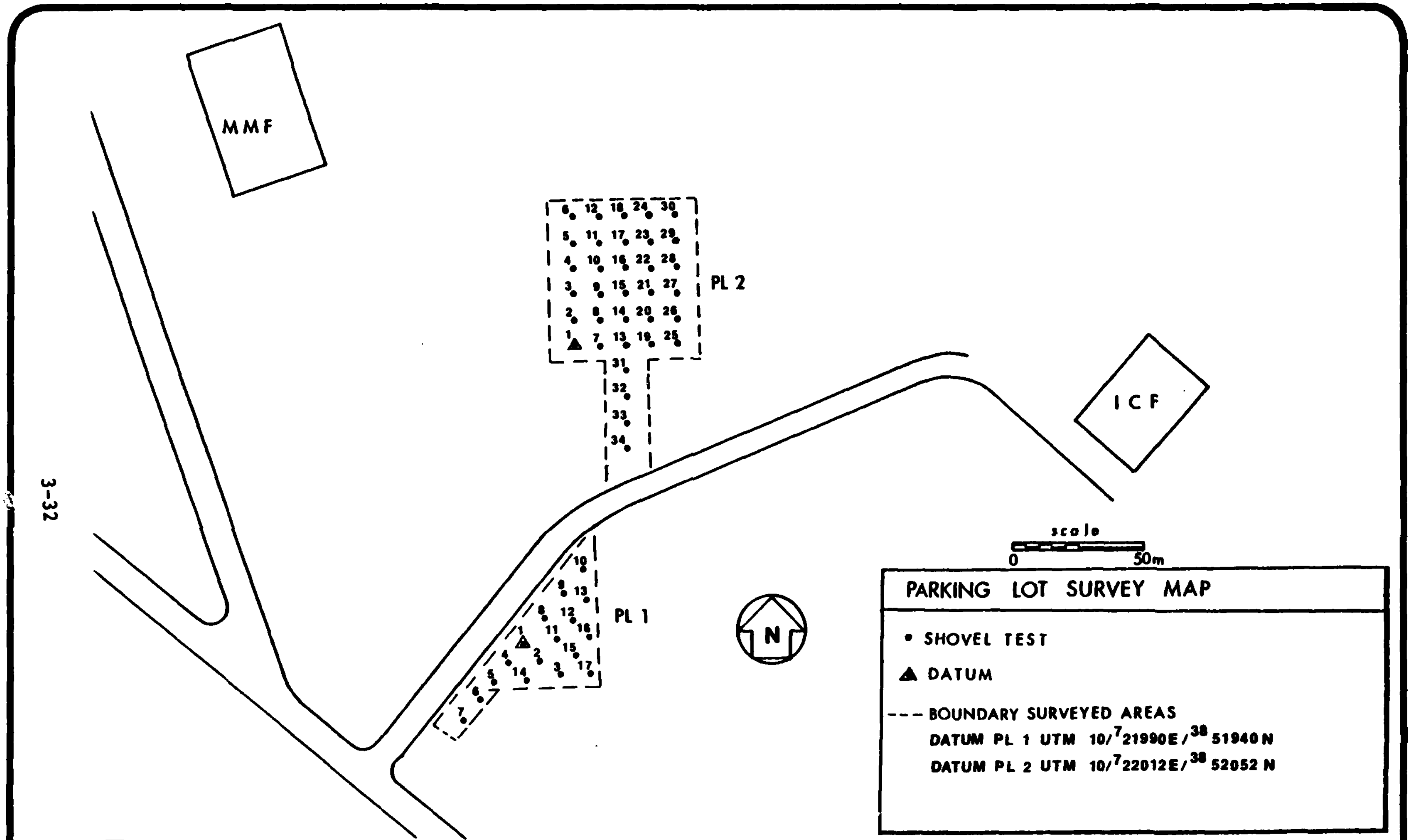

Figure 3-1. MMF and ICF Parking Lot Surveys.

and involved the placement of 51 power poles at about 150 m intervals. Where possible, the route followed existing power lines and access roads. Where access roads were not present, four-wheel drive vehicles were used for pole and line placement.

HDR conducted a preliminary archaeological field reconnaissance on the 69 KV power line route in the summer of 1980 after the COE had completed a cadastral survey of those portions of the route that did not follow existing power lines. Using existing power lines or COE stakes as the centerline, HDR archaeologists surveyed a 30 m corridor in zigzag transects. Discretionary uncontrolled STPs were also excavated in areas of dense vegetation or to examine erosion cuts and rodent burrows. HDR identified two archaeological sites (SBa-1174 and -1175) within the areas of potential impact. These sites have since been determined to be one site and have been combined under one site number (SBa-1174).

Revisions in the powerline route were made in December 1980 and CCP was directed by the COE to survey the new alignment. The sand dune physiography typical of the San Antonio Terrace, where sites tend to be buried by shifting sands, does not extend into the survey area. For this reason, CCP did not employ subsurface survey, but rather relied upon close interval transect surface inspection of the ground. The survey area is characterized by dense vegetation including grasslands, manzanita scrub, sage scrub, and oak woodland.

CCP's field reconnaissance took place during February and March 1981 and consisted of an intensive visual inspection of an area ranging from 20 m to 40 m in diameter around each of the proposed pole emplacement locations. A 30 m corridor along the linear alignment of the 69 KV power line was surveyed in 5 m interval transects using the proposed pole locations as centerline.

In addition to SBa-1174, CCP's reconnaissance identified SBa-1052, and -1066 as being within the areas of anticipated impact from the 69 KV power line. As access road construction was not required, these impacts were limited to only the pole emplacement locations. The COE directed CCP to conduct test excavations at those pole locations that fell within the immediate vicinities of the above archaeological sites. Site descriptions and a discussion of the testing programs undertaken at SBa-1052 and -1066 are provided below. Because additional impacts requiring extensive mitigation occurred at SBa-1174, discussions pertaining to this site are included in a following section of this chapter.

SBa-1052 (Figure 3-2)

Immediate Environmental Context: SBa-1052 is situated on top of a north-south trending ridge between two roads. Site soils are argillec and predominant vegetation consists of oak chaparral. An intermittent drainage is located approximately 400 m east of the site.

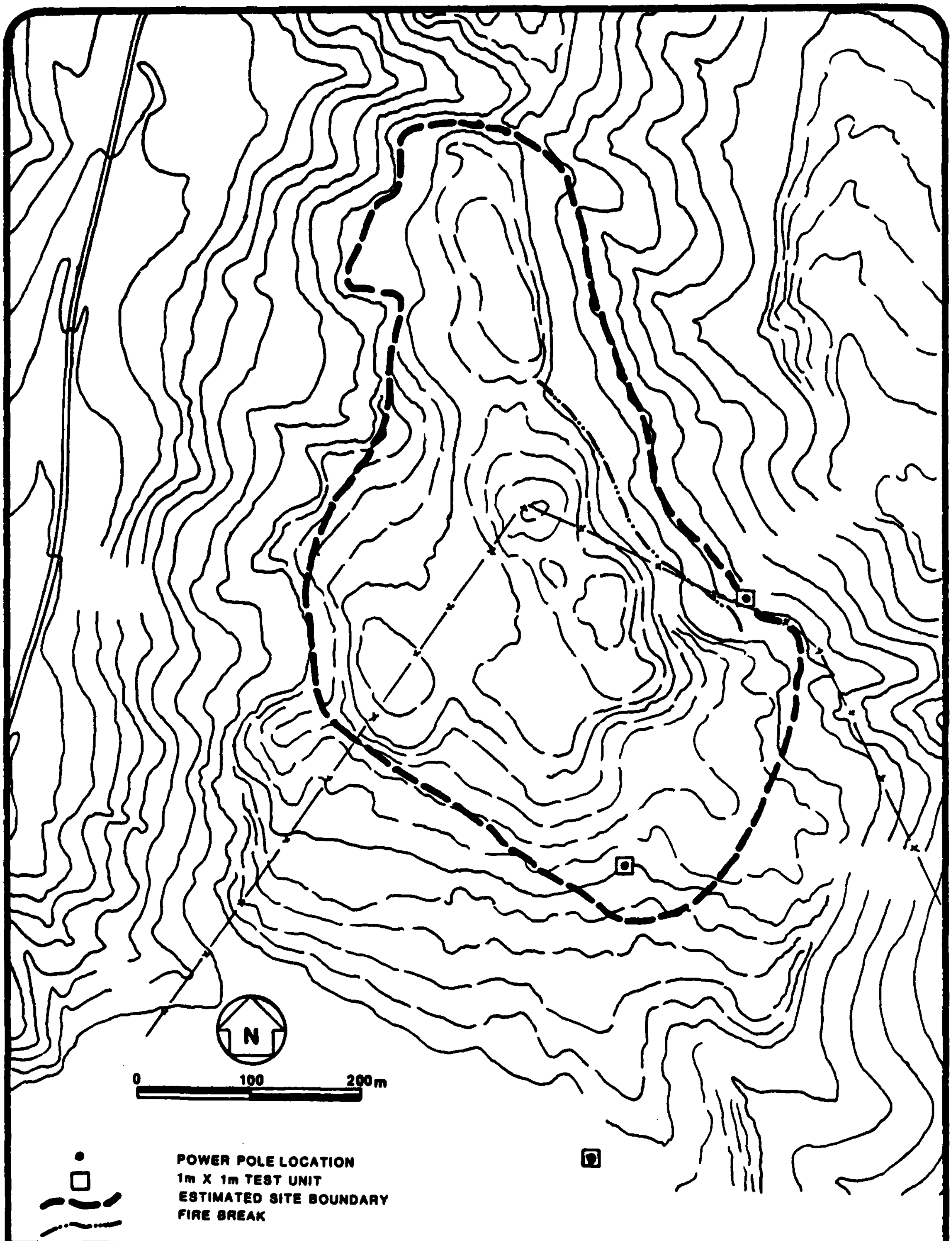

Figure 3-2. SBa-1052.

Gross Site Characteristics: SBa-1052 was first located by Spanne in 1973, who described it as a light to moderate surface scatter of chipping waste (Monterey chert) distributed over two adjacent hilltops and in the intervening saddle. Spanne observed clusters of cracked cobbles in protected areas of the site, such as in the saddle, and one bifacially pitted ovoid cobble of fine-grained igneous rock was found on the surface. Spanne estimated that the site extended approximately 210 m along its north-south axis and approximately 80 m along its east-west axis. Depth was estimated at 30 cm to 60 cm.

SBa-1052 was relocated during CCP's survey of the 69 KV power pole alignment. Heavy ground cover (grass and chaparral) obscured surface visibility over much of the site. CCP's investigations were confined to that area of the site traversed by the power line. Cultural materials observed on the surface consisted of a scatter of chipping debris (primarily Monterey chert) and fire affected rock. Shell was also noted. Because of the heavy vegetation cover, estimated horizontal site definition was based primarily upon materials observed in road cuts. As the result of CCP's investigations, the horizontal boundaries were found to extend about 240 m south and east from Spanne's original south boundary. Subsurface cultural materials were encountered to depths of 30 cm. Previous impacts to the site include several jeep trails and a fence line.

Description of Investigations: Surface materials were not collected or systematically mapped at SBa-1052. A 1 m x 1 m test unit was excavated at each of the three power pole locations that fell either within or near the estimated boundaries of SBa-1052. Unit 1 was located along the northeastern edge of the site and Unit 2 was outside the site boundary as recorded by Spanne. All three test units were excavated in arbitrary 10 cm levels. Unit 1 was excavated to a depth of 40 cm, and Units 2 and 3 were excavated to depths of 30 cm. One STP was placed in Unit 1 to a depth of 40 cm below the bottom of the unit where solid diatomacious earth was encountered. STPs were excavated in Units 2 and 3 to a depth of 80 cm below the bottom of the units.

The results of CCP's testing program at SBa-1052 are summarized as follows: Unit 1 yielded a small number of chipped stone flakes, metal and carbon from the first three levels, while Level 4 and the 40 cm STP placed in the bottom of the unit were devoid of cultural material. Eight lithic flakes, retrieved from the three levels, constituted the only cultural material recorded from Unit 2.

On the basis of data obtained from the testing program described above, it was the consensus of CCP and COE archaeologists that further archaeological investigation at SBa-1052 was not required and that careful monitoring of ground altering activities attendant to power pole placement would complete the mitigation program. It should be noted that this consensus applies specifically to this project only.

VTN archaeologists monitored the power pole emplacements in June 1981; no cultural materials were encountered during monitoring activity.

SBa-1066 (Figure 3-3)

Immediate Environmental Context: SBa-1066 is located east of Lompoc-Casmalia Road and south of San Antonio Creek in the Purisima Hills. Predominant vegetation consists of sage scrub, with riparian plant communities found in the vicinity of the intermittent stream flowing northwest across the southern edge of the site.

Gross Site Characteristics: Originally recorded by Spanne in 1973, SBa-1066 was described as a scatter of Monterey chert chipping waste ranging from trace to light in density and covering an area of approximately 145 m x 75 m to a maximum depth of about 80 cm. Surface artifacts observed by Spanne included two cores, one basal fragment of a percussion-flaked blade (Monterey chert), and an anvil stone. Spanne noted that the site had been largely destroyed as a result of road grading and quarrying activity.

SBa-1066 was relocated by HDR archaeologists in 1980, possibly during their survey of the preliminary 69 KV power line, although HDR's survey report does not mention the site. HDR noted numerous percussion flakes on the surface and artifacts included one bifacially ground mano, one bifacially flaked blade and one anvil stone. HDR also recorded the presence of fragmented small mammal bone. Observable cultural materials covered an area of approximately 150 m x 80 m with a depth of approximately 90 cm visible in cut areas of the site. HDR noted additional site disturbance resulting from a borrow pit and a swath bulldozed through the site for a power line and access trail.

CCP located a portion of SBa-1066 during the survey of the 69 KV power pole alignment. A sparse flake scatter consisting of nine Monterey chert and chalcedony flakes was observed in the vicinity of power pole 3. The survey crew noted considerable displacement of artifactual materials due to site disturbance. The materials described by Spanne and HDR were not observed by the CCP field crew.

Description of Investigations: The locations of all surface finds were recorded in the field using a transit and stadia rod. Surface artifacts were not collected, but were plotted on the site map.

One 1 m x 1 m test unit was placed at the proposed location of pole 3. The unit was excavated in arbitrary 10 cm levels to a depth of 1 m, and a soil sample was obtained from each level. One STP was excavated in two 40 cm levels below the 100 cm level. The unit yielded a total of 13 chipped stone flakes. A prismatic blade (drill) was found near the south wall of Level 3. Levels 9 and 10 and the STP were devoid of cultural materials.

The 69 KV power pole emplacement were monitored by VTN archaeologists in June 1980. No cultural materials were encountered during monitoring activities.

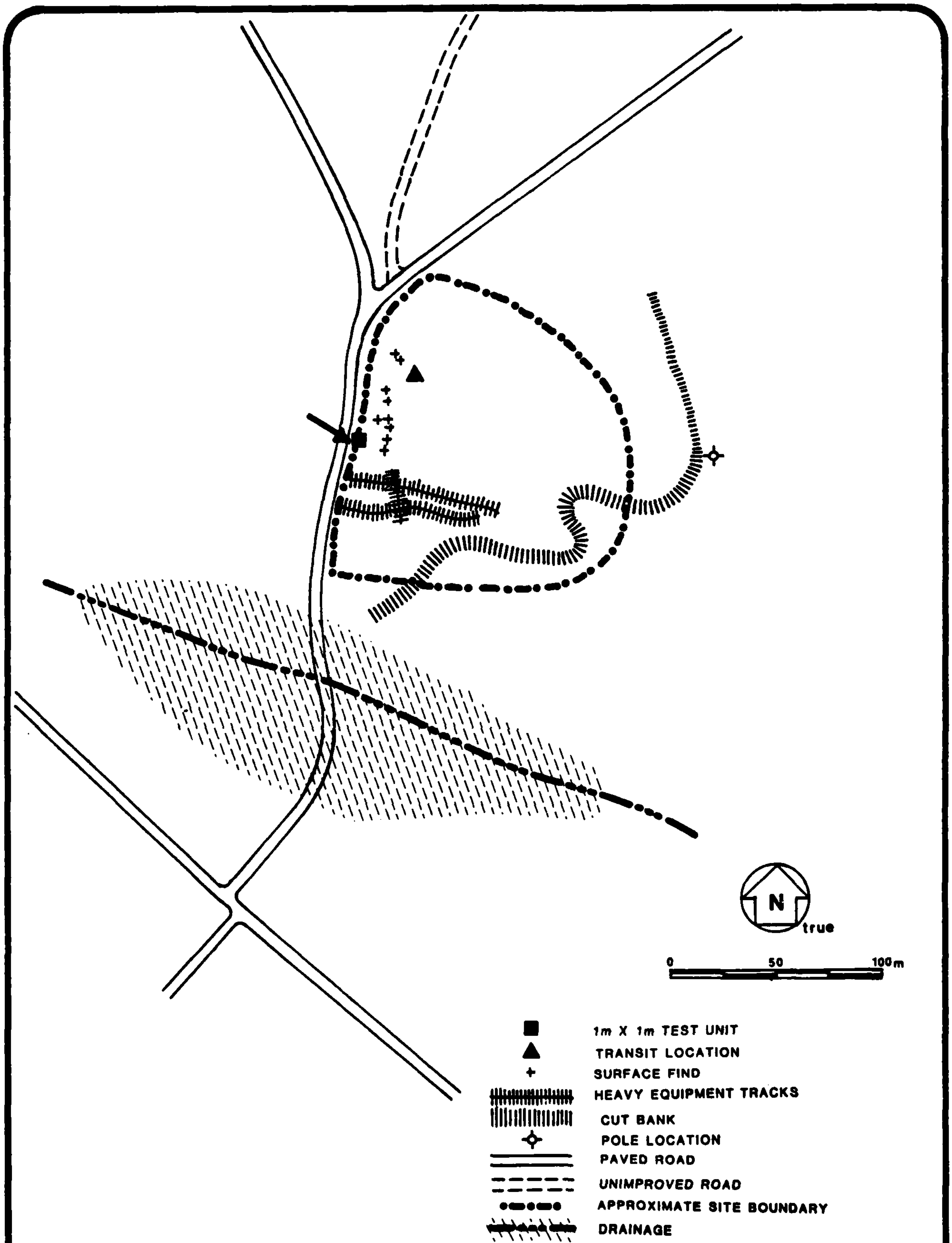

Figure 3-3. SBa-1066.

Stage Storage Facility (SSF)

The SSF is situated in the southern portion of the San Antonio Terrace. Oval in shape, the SSF zone of impact encompasses an area of approximately 120,000 m^2. A substantial security fence will surround the entire project area. Construction plans also included an additional access road to the facility. A portion of the SSF project area was modified by a prior episode of construction, including buildi · 1836, which is still present within the project zone.

The initial cultural resource studies relevant to the construction of SSF were conducted by HDR in the fall of 1979. The access road alignment (portions of which were graded prior to the archaeological survey) was surveyed in parallel zigzag transects at 10 m to 20 m intervals. The area between the access road and the line of the security fence was surveyed in 20 m to 25 m transect intervals, and the security fence alignment itself was examined in 10 m interval parallel transects.

Two previously unknown archaeological sites (SBa-535 and -1070E) were recorded as a result of HDR's investigation. In addition, the site boundaries of SBa-1170, -1171, and -706 were revised and enlarged. Based upon HDR's findings, revisions were made in proposed security fence, access road, and power transmission alignments to avoid or minimize impacts to these archaeological resources.

CCP's investigations of the areas included in the revised SSF siting plan were carried out in March 1981 and entailed an intensive surface survey and limited subsurface testing within the potential impact zones. A 60 m wide corridor surrounding the existing buildings and extending to the proposed security fence alignment was examined in 5 m interval transects. STP arrays were excavated at the locations of the six surface finds and three 1 m x 1 m test units were excavated at SBa-1070E. CCP's testing program resulted in the recordation of a highly disturbed, but previously unknown site (SBa-1778), within the SSF zone of impact.

Site descriptions and a discussion of investigations undertaken by HDR and/or CCP at SBa-535, -1170E, -1171 and -1778 are provided below. Because SBa-706, and -1170 were also investigated in support of the Fiber Optics Communication Line (FOCL) discussion pertaining to these sites is included in the FOCL section of this chapter. A portion of the FO trench did pass through the periphery of SBa-1070E; however, as archaeological investigations at this site were undertaken in conjunction with the SSF, the site is included in this section. The FO cable trenching was monitored by VTN and is included in the discussion of SBa-1070E below.

SBa-535

Immediate Environmental Context: SBa-535 is located in the southern portion of the San Antonio Terrace on a low intermediate dune ridge. Soils are loose tan sand which support sparse coastal sage scrub dune phase vegetation. The site is adjacent to a substantial wetland.

Gross Site Characteristics: Surface survey located two concentrations of fire affected rock and chipped stone flakes deposited within a 100 m x 80 m area. The two loci are deposited on adjacent dune tops. No faunal remains were observed. The vertical dimensions (if any) of the site are unknown.

Nature of Investigations: SBa-535 would have been impacted by construction of the SSF security fence had the fence alignment not been revised to avoid impacting the site. No subsurface archaeological investigations were undertaken.

SBa-1070E

Immediate Environmental Context: The site is situated on the top of a dune of intermediate age 100 m south of SBa-1178. Vegetation consists of coastal sage scrub.

Gross Site Characteristics: The site measures 125 m x 250 m and has a depth of at least 80 cm. The deposit is a sparse scatter of lithic tools and flakes including bifaces, retouched flakes, debitage and fire altered rocks; shell is also present. HDR noted buried cable lines and bulldozing near the southwest tip of the site.

Description of Investigations: HDR discovered the site during their fall 1979 survey of the SSF security fence and access road. No excavations or collection was undertaken by HDR. The site was also encountered by CCP during the revised SSF siting plan survey. CCP conducted limited subsurface testing at SBa-1070E. One large biface was collected from the surface and one STP was excavated to 80 cm in the extreme north edge of the site. Three 1 m x 1 m test units were excavated in 10 cm levels to a depth of 100 cm in those areas of the site where surface indicators suggested the likelihood of highest artifact yield. A total of 112 chipped stone flakes were recovered from CCP's subsurface testing. One chipped stone flake was retrieved from the STP, and the remainder of the cultural material (including shell, bone and carbon) was found in Units 1 and 2. No cultural material was recovered from Unit 3. Column, soil, and flotation samples were obtained from each unit and processed by CCP's Santa Barbara laboratory personnel.

SSF construction monitoring was carried out by VTN archaeologists in April of 1981. No cultural materials were encountered at this time, and the site was apparently avoided in the construction of the SSF. A single projectile point was recovered during monitoring of the FO trench line in March 1982.

SBa-1071

Immediate Environmental Context: SBa-1071 is located in a swale and side slope of an intermediate dune. Vegetation consists of coastal sage scrub which has partially stabilized the loose sandy matrix. A fresh-water pond is situated below the site.

Gross Site Characteristics: SBa-1171 is described as a very low density scatter of chipped stone waste flakes and shell measuring 30 m in diameter. The vertical dimensions are unknown. HDR notes that active slope wash or dune sand movement may have obscured the ground surface.

Nature of Investigations: The site was first recorded by Spanne in 1971. HDR relocated the site in 1980 during the initial security fence alignment survey. As a result of the fence alignment revision, the site was not impacted and therefore no archaeological work was undertaken.

SBa-1778

Immediate Environmental Context: SBa-1778 is located atop a dune of intermediate age approximately 1 km north of the rim of the San Antonio Creek drainage basin. The vegetation of the area is dune phase coastal sage scrub with a line of eucalyptus trees planted 400 m southeast as a windbreak. The nearest wetland is small and 150 m to the north.

Gross Site Characteristics: The site is roughly coterminous with the SSF construction zone (approximately 400 m x 275 m). Prehistoric cultural materials were discovered at five separate locations within the project area and one find (surface collection 6) was encountered just outside the limits of construction and north of SBa-1070E. Constituents include one projectile point, chipped stone flakes, fire affected rock, and bone. Prehistoric cultural materials were found to be mixed with recent historic materials to a depth of 40 cm.

Description of the Investigations: A total of 45 STPs were excavated by CCP archaeologists in x-shaped arrays containing two STPs at 5 m intervals in each of the cardinal directions emanating from a central STP placed at the locations of the five surface finds. An additional 18 STPs were excavated on lines bearing 10 degrees true and 100 degrees true from surface find 6 and two STPs were excavated at 20 m intervals bearing south at 10 degrees true from the center point. Each STP was dug in two 40 cm levels to a maximum depth of 80 cm. Soils were screened through 1/16 inch mesh. Soil samples were obtained from each level and processed by CCP's Santa Barbara laboratory. Prehistoric cultural materials were underlain by recent construction materials and shrapnel to the limit of their vertical extent. These data and the general appearance of the project area demonstrate that the site is heavily disturbed and that the prehistoric artifacts are not in situ. CCP and COE archaeologists agreed that further investigation at SBa-1778 was not warranted.

Construction monitoring of the SSF was carried out by VTN archaeologists in April 1981 and resulted in the recovery of one fused shale projectile point (tip fragment) and a fractured cobble of Monterey chert from SBa-1778.

Rail Transfer Facility (Figure 3-4)

The Rail Transfer Facility (RTF) is located within the northwest portion of the San Antonio Terrace just south of the Southern Pacific rail line. The facility encompasses an area of approximately 35,000 m^2 and is situated within a dune swale just north of the intersection of two roads. The impact zone trends northwest and then arcs southwest to connect with the existing Southern Pacific rail line. A short access road was constructed to the facility.

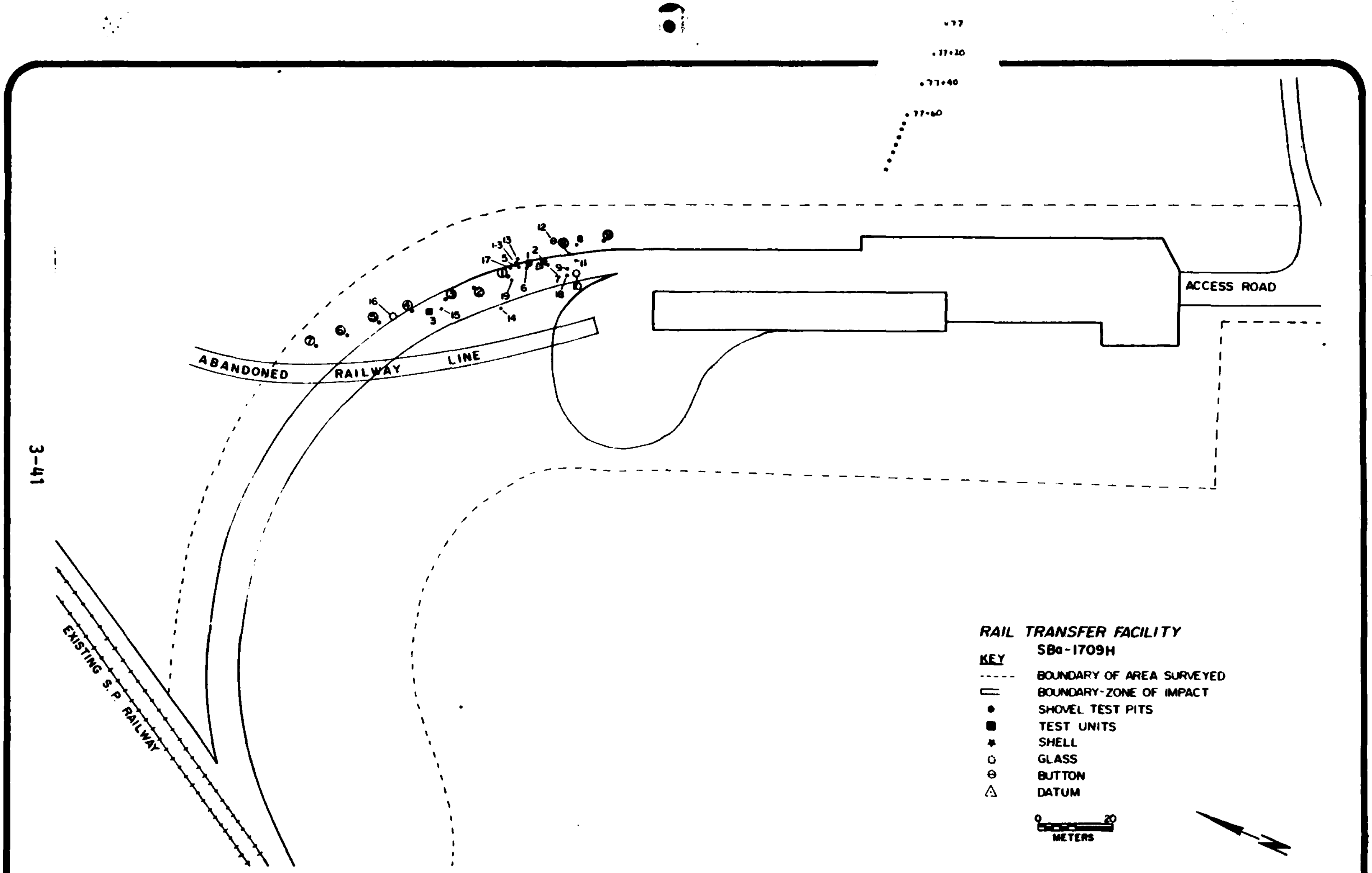

Figure 3-4. SBa-1709H (Rail Transfer Facility).

HDR archaeologists undertook a preliminary field reconnaissance of the RTF construction impact area in 1979 during the initial MX planning studies. The RTF and access road impact zones were surface inspected in 10 m interval transects. Prior to HDR's survey, the access road had been cleared of vegetation and bulldozed. HDR noted excellent ground visibility throughout the survey area.

An abandoned rail line bed, trending to the northwest across the project zone, was discovered by HDR's survey crew. Fragments of metal spikes, railbed timbers, recent trash and glass, and shell were observed on the surface in the vicinity of the old railbed. Other than possibly the shell, no prehistoric remains were encountered during the course of the survey.

HDR determined that a portion of the abandoned railbed was likely to be destroyed by the construction of the SSF. After consultation with the California State Office of Historic Preservation, HDR archaeologists decided that the railbed did not constitute a significant resource and the finds therefore were not recorded as an archaeological site.

In the interim period between the RTF planning stage and the completion of the final design plans, 10 m interval survey transects were found inadequate given the dynamic dune physiography of the San Antonio Terrace. For this reason and to determine whether or not subsurface prehistoric materials were associated with the shellfish remains, CCP was directed by the COE to conduct additional close interval survey and subsurface testing of the RTF construction zone.

CCP's investigations took place in March 1981 and entailed a surface reconnaissance at 3 m interval transects through the impact zone and subsurface testing through the excavation of nine STP's and three 1 m x 1 m test units. SBa-1709H was recorded as a result of CCP's work at the RTF. A site description and a discussion of CCP's testing program are provided below.

SBa-1709H

Immediate Environmental Context: The site is situated in a dune swale within an area of intermediate dunes in the northwest portion of the San Antonio Terrace. Vegetation is sparce and consists of dune phase coastal sage scrub.

Gross Site Characteristics: The site measures approximately 100 m x 35 m horizontally and consists of a locus of historic remains including glass, a button, rusted metal (including rail spikes, tieplates and a pick head), and shell. An abandoned railbed traverses the site. The majority of materials were found on the surface, although shrapnal fragments were recovered to a maximum depth of 80 cm. No prehistoric remains are present.

Nature of Investigations: CCP conducted a controlled surface collection of the site. Prior to collection, the locations of all surface finds were recorded with transit and stadia rod in reference to the site datum. Nine STPs were excavated in two 40 cm levels at 10 m intervals along a base line established on the northeast side of the abandoned rail spur in the vicinity of

the surface finds. In addition, three 1 m x 1 m controlled units were excavated in 10 cm levels to depths ranging from 30 cm to 90 cm. Two of these units were placed in the area of the surface finds and one unit was placed outside the surface concentration to serve as a control. All soils were screened through 1/16 inch mesh.

The majority of the material recovered from both the STPs and the controlled units consisted of small fragments of metal. An occasional sliver of glass and small amounts of carbon were also recovered. Soil samples were obtained but not processed, as the site yielded no prehistoric constituents and contained no evidence of a midden.

Construction monitoring of the RTF was carried out by VTN archaeologists during March, April, and May 1981. Several metal objects including spikes, a pickhead, tieplates, and a porcelainized iron cooking vessel fragment, as well as two wooden railroad ties were recovered during monitoring at the RTF. The site may represent a work camp associated with early railroad construction or perhaps the sugar beet industry (see Appendix II). The site is now 100 percent destroyed.

Western Horizontal Test Structures

The MX missile test facility siting plans include the proposed construction of four Horizontal Test Structures (TS-1 and -2 to the east, TS-3 and -4 to the west) and two Test Pads (TP-1 and TP-2) within the north central portion of the stabilized dunes of the San Antonio Terrace. Access roads will connect all of the eastern and western shelters with the Missile Assembly Building (MAB). The archaeological work undertaken in the areas involved separate investigations at different times. Only the western shelters are discussed here; the eastern shelters are discussed in a succeeding section of this chapter.

HDR archaeologists conducted a preliminary survey of the siting areas planned for the construction of the western shelter facilities and their associated access roads in the fall of 1979. The impact areas of the proposed facilities were surface inspected at 5 m to 10 m interval transects. A 60 m wide corridor along each access road was surveyed in 15 m interval transects.

HDR's field reconnaissance resulted in the identification of a previously unknown archaeological site (SBa-576) within the impact zones of TS-3 and TP-1. In addition, isolated cultural remains (Locus 4) were identified within the impact areas of TS-4 and TP-2. Subsequently, because of potential impacts to significant archaeological resources and additional biological constraints, the horizontal shelter layout was revised. The revised layout avoided both SBa-576 and Locus 4 and no archaeological testing was undertaken at these sites.

Additional survey by HDR archaeologists (using the procedures described above) on the revised siting plan impact areas resulted in the discovery of additional cultural remains in the vicinity of both facility locations and in the construction access road to TS-3.

Surface mapping and limited STP testing of these areas was undertaken by UCSB-OPA in March 1980 under contract to HDR. The sites were subsequently recorded as SBa-1153 (construction access road to TS-3), SBa-1154 (TS-3), and SBa-1155 (TS-4). SBa-1153 was avoided during the blading of the construction access road to TS-3 and plans have not been implemented for the construction of TS-4 in the vicinity of SBa-1154. No further archaeological work was undertaken at these two sites. Two additional sites, SBa-1179 and SBa-1718 were discovered by HDR archaeologists during resurvey of the proposed TS-3 access road as revised by design changes in May 1980.

In addition to SBa-1179 and -1718, two sites--SBa-1180 and -1180S--were encountered by VTN monitors during construction of the access road to TS-3. HDR undertook testing programs at all of these sites during September and October 1980. Additional testing at SBa-1718 was carried out by the COE in December 1980.

CCP conducted additional investigations at SBa-1155 in March 1981, prior to the construction of TP-1 at TS-4. An additional archaeological site, SBa-1181, was discovered by VTN monitors during the blading of the access road to TP-1. Limited STP testing of the site was undertaken by HDR in August 1980.

Site descriptions and a discussion of the various archaeological investigations at each of the western shelter sites are provided below. For the sake of clarity, sites located by HDR during the surveys of the original and revised western shelter layout that were determined not to be subject to adverse impact (SBa-576, Locus 4, SBa-1153 and -1154) are grouped together. The remainder of the sites are discussed in terms of the area of impact.

SBa-576

Immediate Environmental Context: This site is situated on a small promontory adjacent to a dune swale containing a fresh water pond. Site vegetation consists of coastal sage scrub and soils are comprised of tan sandy loam.

Gross Site Characteristics: SBa-576 is described as a shell midden covering an area of approximately 30 m x 30 m containing chipped stone artifacts, faunal remains and fire affected rock. According to HDR, the deposit has not been disturbed. The vertical dimensions of the site are unknown.

Nature of Investigations: SBa-576 was avoided by design changes in the western shelter layout, and the site therefore has not been tested.

Locus 4

Locus 4 is described as three possibly wind transported flakes found on the side slopes of a stabilized dune. The location of the find was not tested or recorded as an archaeological site. Additional information is recorded in the report prepared for HDR by Haley and Serena (1980).

SBa-1153

Immediate Environmental Context: The site is situated in a large swale centrally located in the intermediate dunes. A wetland plant community with occasional standing water lies 50 m north and east of the site. Although remnants of the indigenous coastal sage scrub plant community can be found at the site, introduced species (Pinus sp., grasses and iceplant) predominate. Soils consist of loose coarse sand.

Gross Site Characteristics: The site includes two loci deposited within an area of approximately 4,500 m^2. The northern locus is a moderately dense lithic and shell scatter while the southern locus contains dark soil, chipped and ground stone and shell. There is considerable evidence of disturbance and rodent activity. Limited testing of a portion of the southern locus indicates a depth of at least 1 m.

Nature of the Investigations: UCSB-OPA archaeologists surveyed the surface of the site in 3 m to 5 m transect intervals and excavated 22 STPs ranging in depth from 90 cm to 115 cm along the north boundary of the southern locus. Two chipped flakes and a small amount of shellfish remains were recovered from the subsurface testing. Surface materials, including a biface fragment, were mapped but not collected. Impacts to the site were avoided by design changes and no further testing was undertaken.

SBa-1154

Immediate Environmental Context: Situated in a swale in the intermediate dunes, the deposit is bordered on the north by a willow thicket. Coastal sage scrub has partially stabilized the surrounding dune ridges.

Gross Site Characteristics: The site is a low density deposit of chipped stone and shell scattered over an area 15 m wide and 150 m long. A possible Haliotis sp. nacre bead fragment was observed on the surface. The site appears to be undisturbed.

Nature of the Investigations: UCSB-OPA surveyed the surface of the site in 3 m to 4 m interval transects and excavated 18 STPs at 4 m intervals along the southeast side of surface scatter. The STPs ranged in depth from 90 cm to 115 cm. Soils were screened through 1/8 inch mesh. No cultural materials were recovered from the subsurface testing. Surface materials were mapped, but not collected. Because of design changes, impacts to this site were avoided and no further investigation was undertaken.

Access Road to TS-3

SBa-1179 (Figures 3-5 and 3-6)

Immediate Environmental Context: The site, now destroyed, was located in a small depression on top of a dune ridge. Site soils consisted of dark compacted brown sands surrounded by typical loose dune sands. Vegetation was coastal sage scrub.

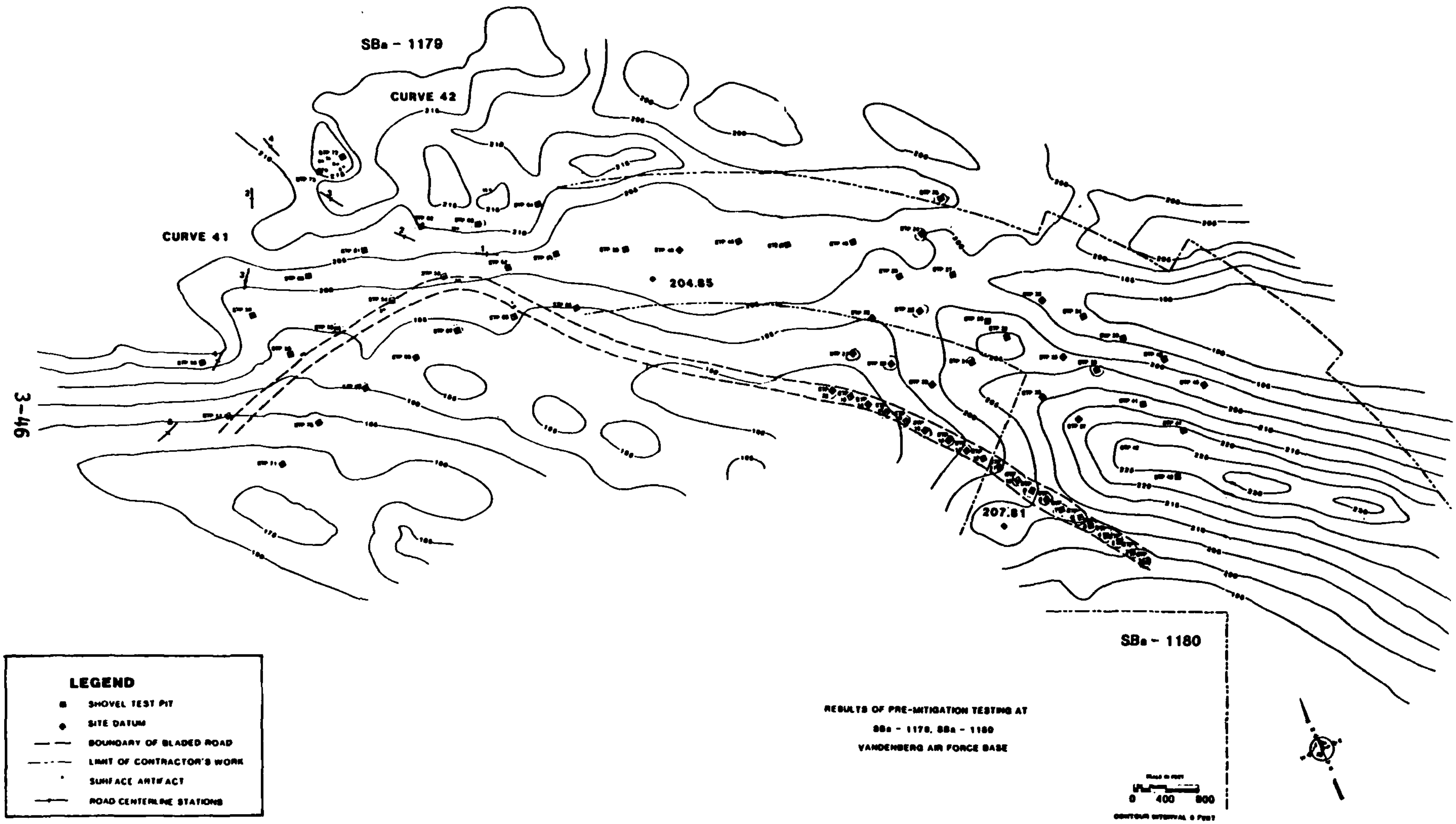

Figure 3-5. SBa-1179 and -1180 (HDR Map).

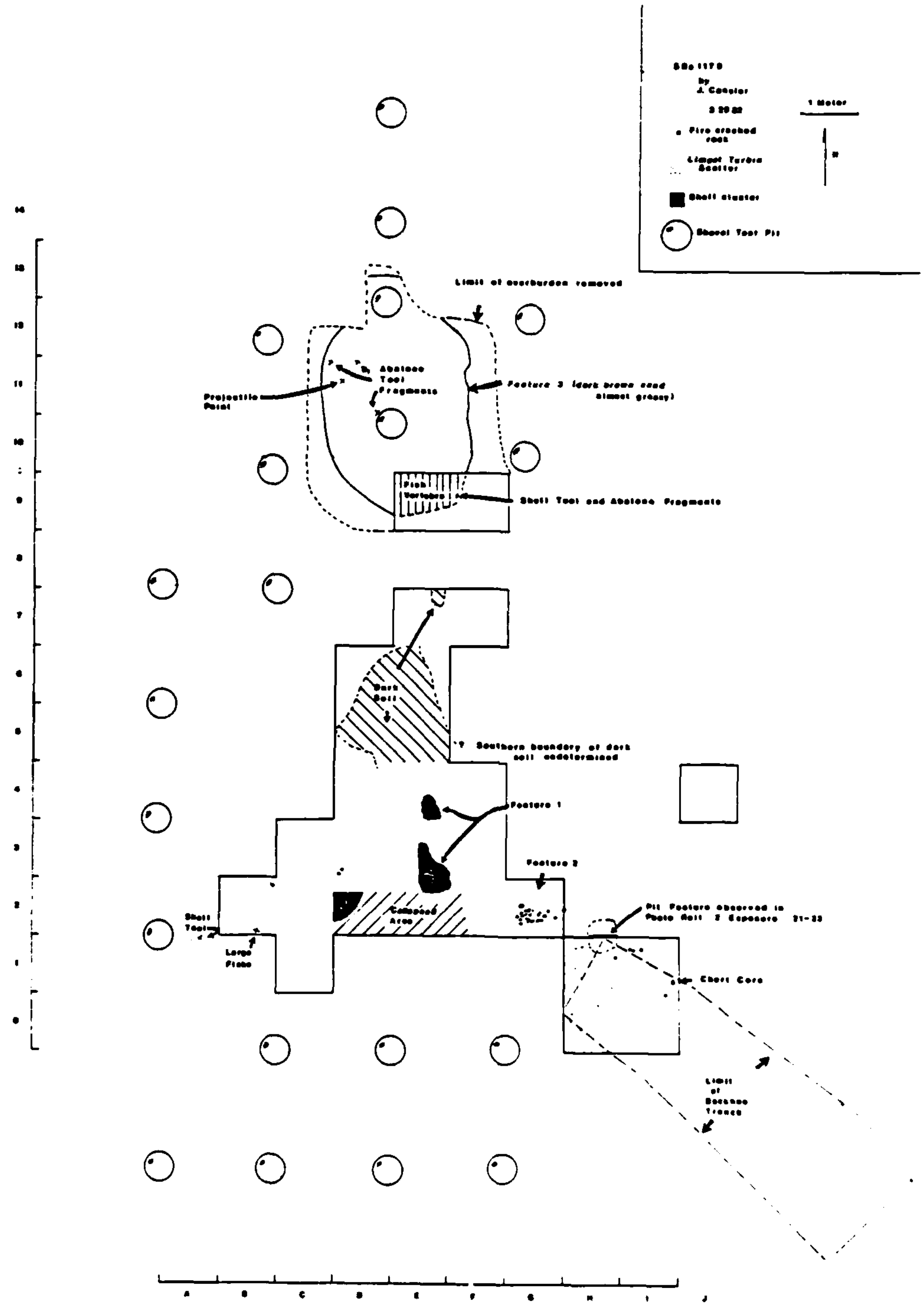

Figure 3-6. SBa-1179.

Gross Site Characteristics: SBa-1179 consisted of a buried deposit extending over an area of 20 m x 20 m. Constituents included chipped stone flakes and tools, fire affected rock, shell, and bone contained in a dark compacted silty soil matrix. Several subsurface concentrations of shell were present, as well as a 50 cm x 50 cm fire altered rock feature. Dark oil stained soils were encountered at a depth of about 2 m. The vertical dimension of the site ranged from 10 cm to over 2 m. Construction of the access road to TS-3 totally destroyed the site.

Description of Investigations: This site was discovered by HDR archaeologists during their survey of the revised access road alignment to TS-03 in July 1980. HDR archaeologists began premitigation recovery in the same month and salvage work continued into December 1980. The premitigation testing involved a controlled collection of materials found on the surface and the excavation of 28 STPs to depths of 80 cm to 100 cm. These aided in the determination of the site's horizontal extent and revealed the presence of subsurface materials. Twenty additional STPs were excavated to 80 cm between October and December.

Twenty-seven 1 m x 1 m, one 2 m x 2 m, and one 5 m x 5 m test units were excavated to maximum depths of between 45 cm to 155 cm. The total volume of 17 m^3 of soil was screened through 1/16 inch mesh. In addition, extensive backhoe trenching was undertaken outside the site's boundaries. Approximately 75 percent of the site volume was excavated, including features.

Recovered materials included 1,475 chipped stone flakes and three tools. Shell, bone, and carbon were also retrieved. Soil, column and float samples were processed by CCP's Santa Barbara laboratory and samples were also obtained for C-14 dates.

SBa-1180

Immediate Environmental Context: This site, now at least 25 percent destroyed, was located on a dune ridge east of SBa-1179. Soils consist of loose dune sand semi-stabilized by coastal sage scrub vegetation.

Gross Site Characteristics: SBa-1180 is described by HDR as a low density scatter of Monterey chert pressure flake debitage buried under 1 to 2 feet of dune sand. Numerous small wind polished flakes suggest at least partial secondary deposit. The site covers an area of 20 m x 40 m; disturbance prevented the determination of any vertical dimensions.

Nature of the Investigations: All the work at the site was done by HDR archaeologists and VTN monitors. Although HDR surveyed the TS-3 road alignment, the site was not discovered by monitors until after road grading had begun. Initial surface collection produced 15 artifacts. Subsequent excavation of 44 STPs to a depth of 100 cm recovered subsurface material including chipped stone flakes and shell. In addition to the numerous small polished flakes, four chipped stone tools were recovered. The site may have been totally destroyed during construction of the access road. The extent of the disturbance precluded the determination of primary or secondary deposition.

SBa-1180S (Figure 3-7)

Immediate Environmental Context: The site, now destroyed, was situated on an intermediate dune ridge south of SBa-1180. The soils are loose dune sand semi-stabilized by coastal sage scrub.

Gross Site Characteristics: The site was a low-density lithic scatter covering an area approximately 150 m x 50 m within the access road alignment. The lack of apparent stratigraphy and the high polish on the chipped stone artifacts suggest the site had been secondarily deposited and/or disturbed by grading of the access road. The site was completely destroyed.

Nature of the Investigations: Data recovery was undertaken by HDR and involved the excavation of a 2 m x 2 m test unit to 40 cm. After wall-fall made the excavation of the 2 m x 2 m unit impractical, its size was reduced to 1 m x 1 m and continued to 90 cm, at which depth unstable conditions forced closure of the unit. Ten STPS were excavated to 80 cm after the unit was closed. All soils were screened through 1/16 inch mesh. Twenty-one chipped stone flakes (all over 1/4 inch), eight chipped stone tools and one mano were recovered from the site. Shell and bone were also recovered.

HDR undertook additional data recovery when VTN monitors discovered a dark stratum in the road cut. HDR archaeologists screened a portion of this deposit for artifacts, but found none. Road construction was allowed to continue.

SBa-1718 (Figures 3-8, 3-9, and 3-10)

Immediate Environmental Context: The site is located in a large dune swale 150 m northwest of SBa-1179. Vegetation consists of coastal sage scrub, mesic dune scrub and wetland species including Juncus sp. Site soils consist of gray-brown midden which may be partially of non-cultural origin. Surrounding soils are tan dune sands.

Gross Site Characteristics: The site measures 25 m x 25 m horizontally and is 40 cm deep in those areas tested. Constituents include chipped stone, shell, and fire-cracked rock. A concentration of shell was noted in the northern portion of the site. Much of the deposit is still intact, but buried under the TS-3 access road.

Nature of the Investigations: HDR's investigations were carried out during October, November, and December 1980. After a controlled surface collection, the 14 1 m x 1 m squares were scraped of vegetative debris to a depth of 5 cm. Sixty-six artifacts discovered by this method were collected from the surface. In addition, HDR excavated 55 randomly located STPs within the site. The STPs were excavated in two 40 cm levels to a depth of 80 cm. Soils were screened through 1/16 inch mesh.

The COE conducted further investigations at SBa-1718 during December 1980. Immediately prior to road construction, COE archaeologists excavated two controlled STPs to a maximum depth of 85 cm. Soils in the top levels only (60 cm and 40 cm) of the STPs were screened through 1/16 inch mesh.

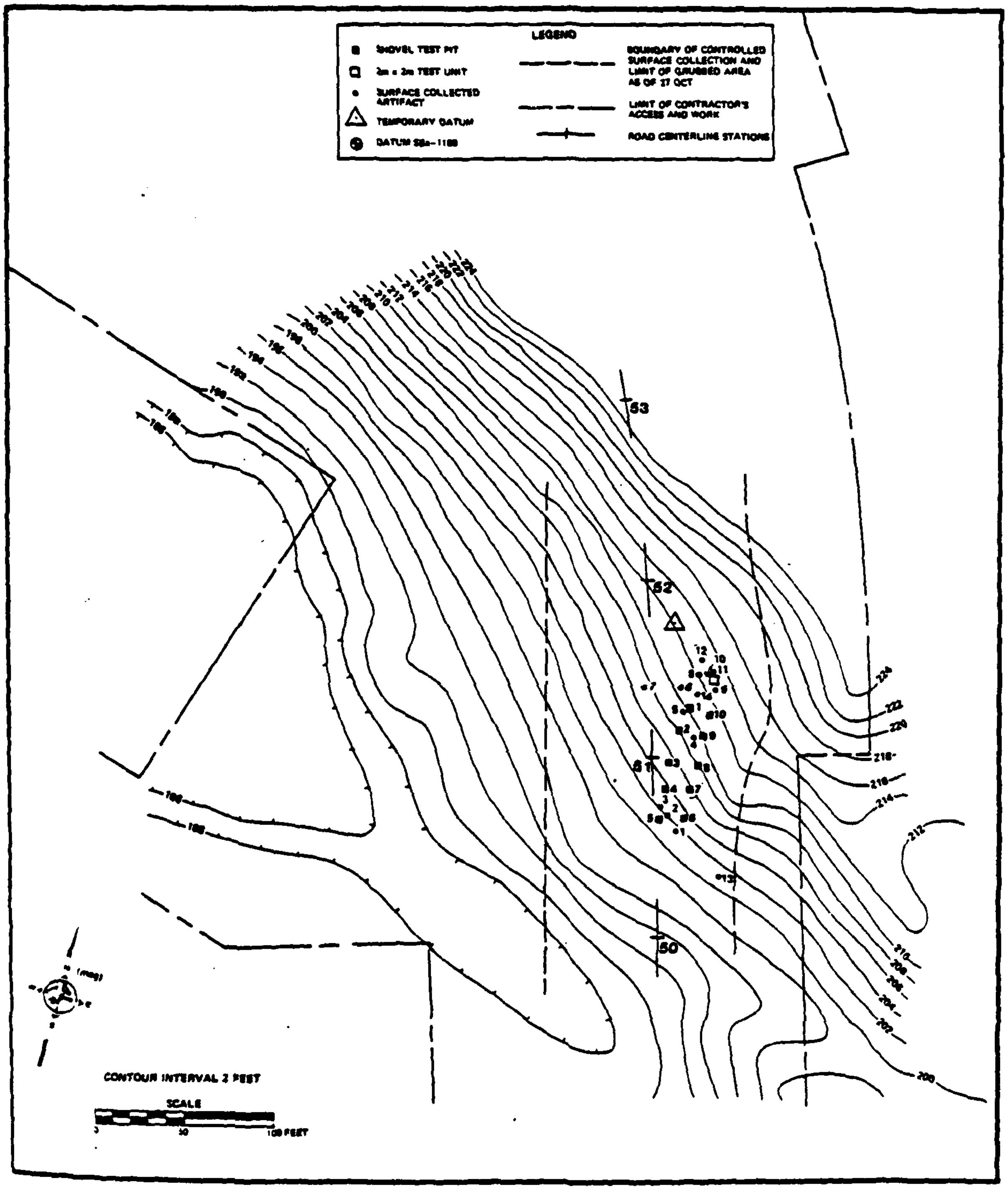

Figure 3-7. Results of Emergency Testing and Salvage at SBa-1180S (HDR Map).

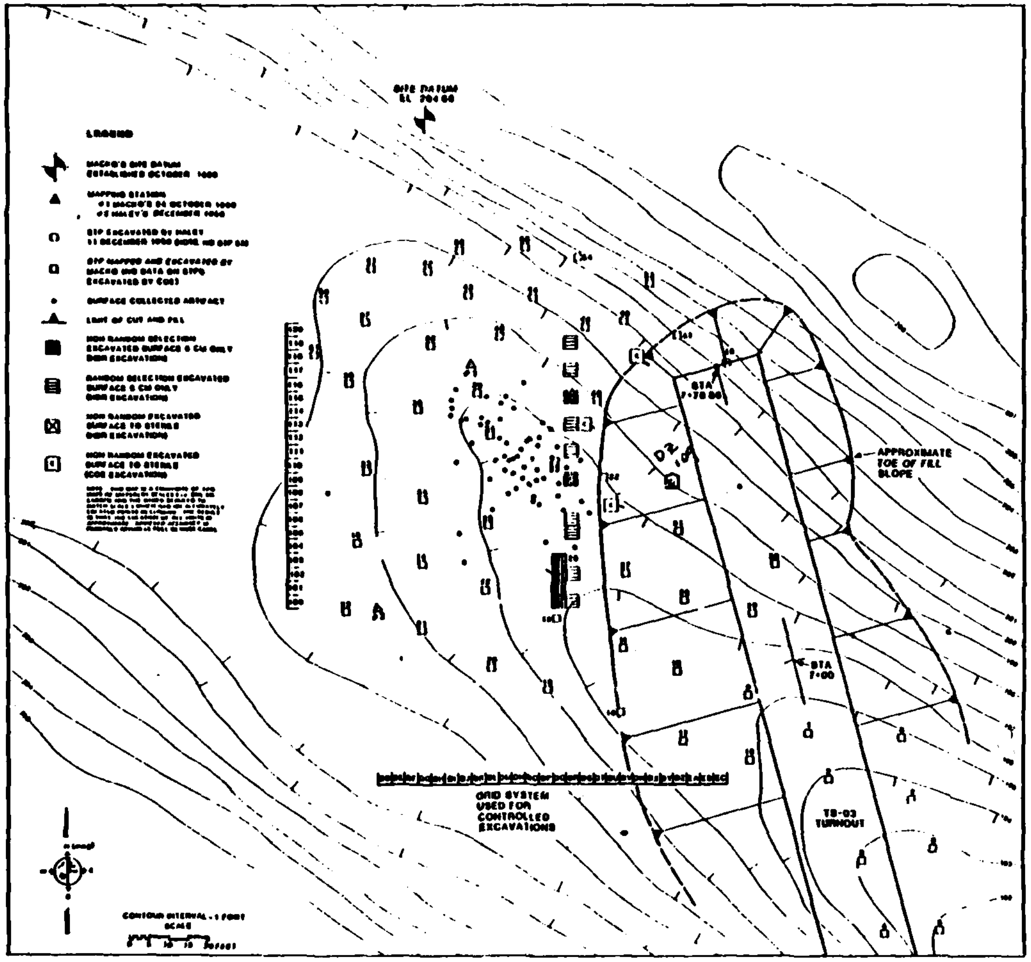

Figure 3-8. Summary of Premitigation and Testing at SBa-1718 (Originally SBa-1179N) (HDR Map).

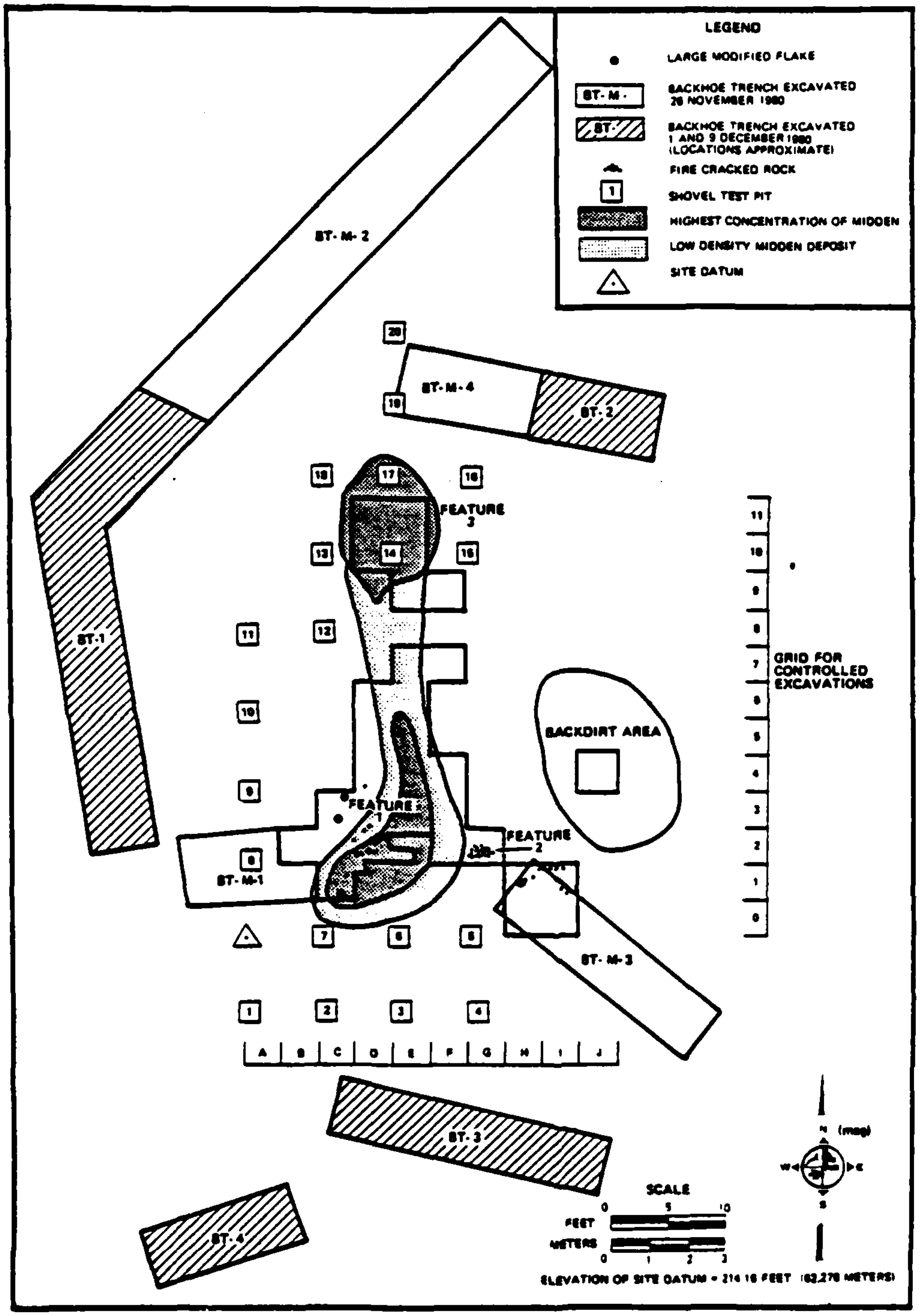

Figure 3-9. Summary of Premitigation and Mitigation Testing at SBa-1718 (Originally SBa-1179N) (HDR Map).

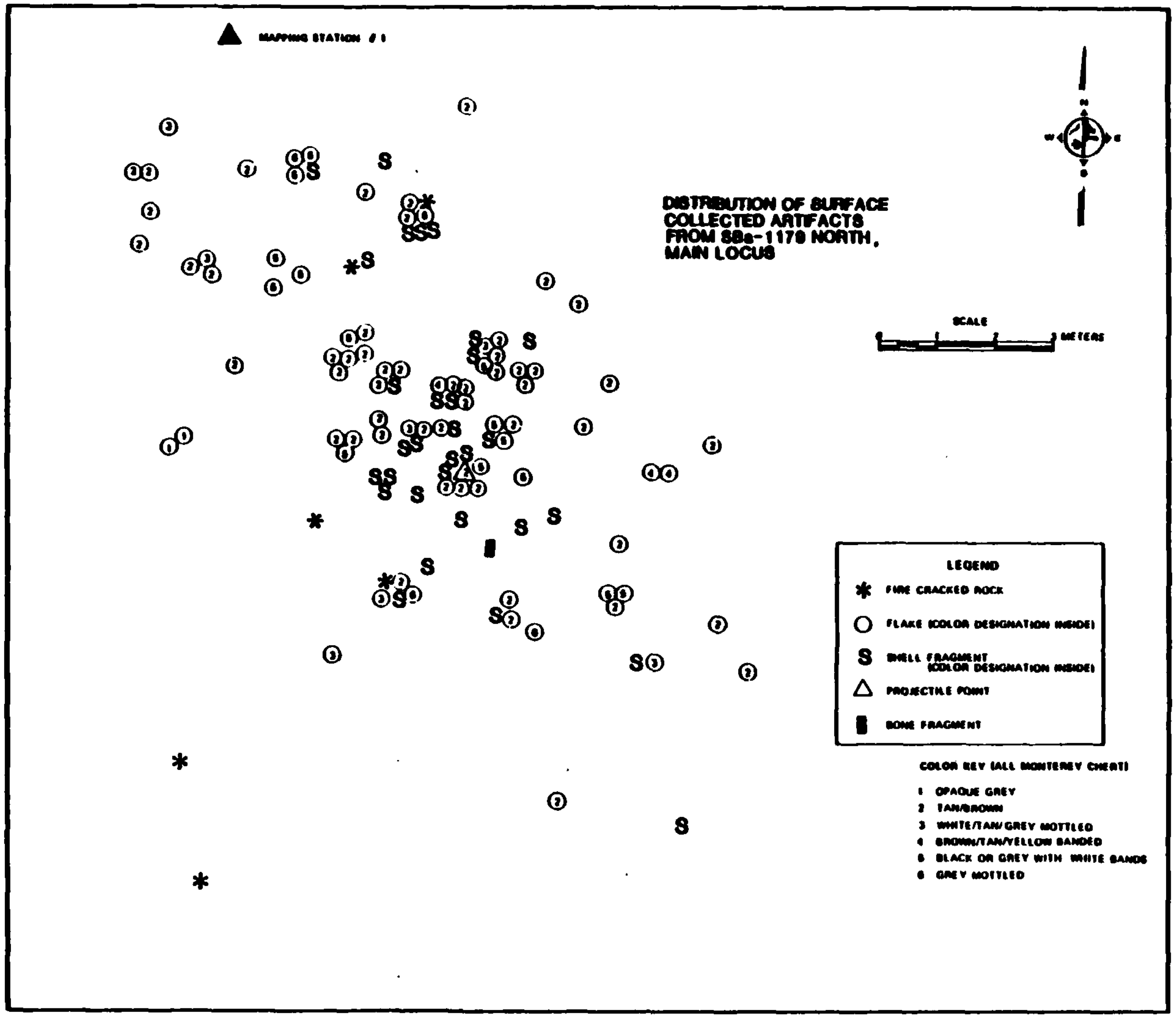

Figure 3-10. Distribution of Surface-Collected Artifacts from SBa-1718 (Originally SBa-1179 North), Main Locus (HDR Map).

In addition, the COE excavated four 1 m x 1 m test units and three .5 m x .5 m control columns to depths ranging from 30 cm to 50 cm. COE excavated a total volume of 3.47 m^3.

Test Pad 1 (TP-1)

SBa-1155 (Figure 3-11)

Immediate Environmental Context: SBa-1155 is situated within a swale and on the flanks of dunes of intermediate age. Loose sand comprises the soil matrix and coastal sage scrub, the vegetation.

Gross Site Characteristics: The site measures approximately 100 m x 150 m in area and is 1 m deep. The surface and subsurface deposit contains chipped stone debitage, biface fragments, and cores of Monterey chert. All these materials appear to be heavily damaged by windblown sand. This suggests that the smaller, lighter materials were deposited at some undetermined point upwind and subsequently displaced to their present location and that the larger materials were deposited on a surface which has undergone substantial wind disturbance. A portion of SBa-1155 may be intact, buried beneath TP-1.

Description of the Investigations: After HDR's initial reconnaissance at SBa-1155, the site was further investigated by UCSB-OPA archaeologists under contract to HDR. UCSB-OPA conducted an intensive surface examination of the site; however, visibility was hampered by dense vegetation. Surface materials were mapped, but not collected. In addition, 12 STPs, ranging in depth from 92 cm to 115 cm, were excavated in two intersecting lines around the northeast edge of the surface scatter. Soils were screened through 1/8 inch mesh. No cultural material or midden soils were recovered from any of the STPs.

Prior to the construction of TP-1, CCP surveyed the site in 5 m interval transects. The locations of nine surface finds were recorded with transit and stadia and then collected. To determine the horizontal distribution of the cultural materials, a total of 99 STPs were excavated in two 40 cm levels to a depth of 80 cm. These were located along transects placed through the apparent center of the site and through areas with higher densities of surface material. In addition, two 1 m x 1 m test units were excavated in 10 cm levels where combined surface and STP data suggested high artifact concentrations. All soils recovered from the STPs and the test units were screened through 1/16 inch mesh.

Three backhoe trenches were excavated without level control by a construction contractor's operator under the supervision of CCP archaeologists. Material from these trenches was partially screened.

A total of 149 chipped stone flakes, in addition to bone, carbon, and shell, was recovered from CCP's investigation. Construction of TP-1 was monitored by VTN archaeologists in April 1981. Two chert flakes and one projectile point fragment were recovered from the construction area.

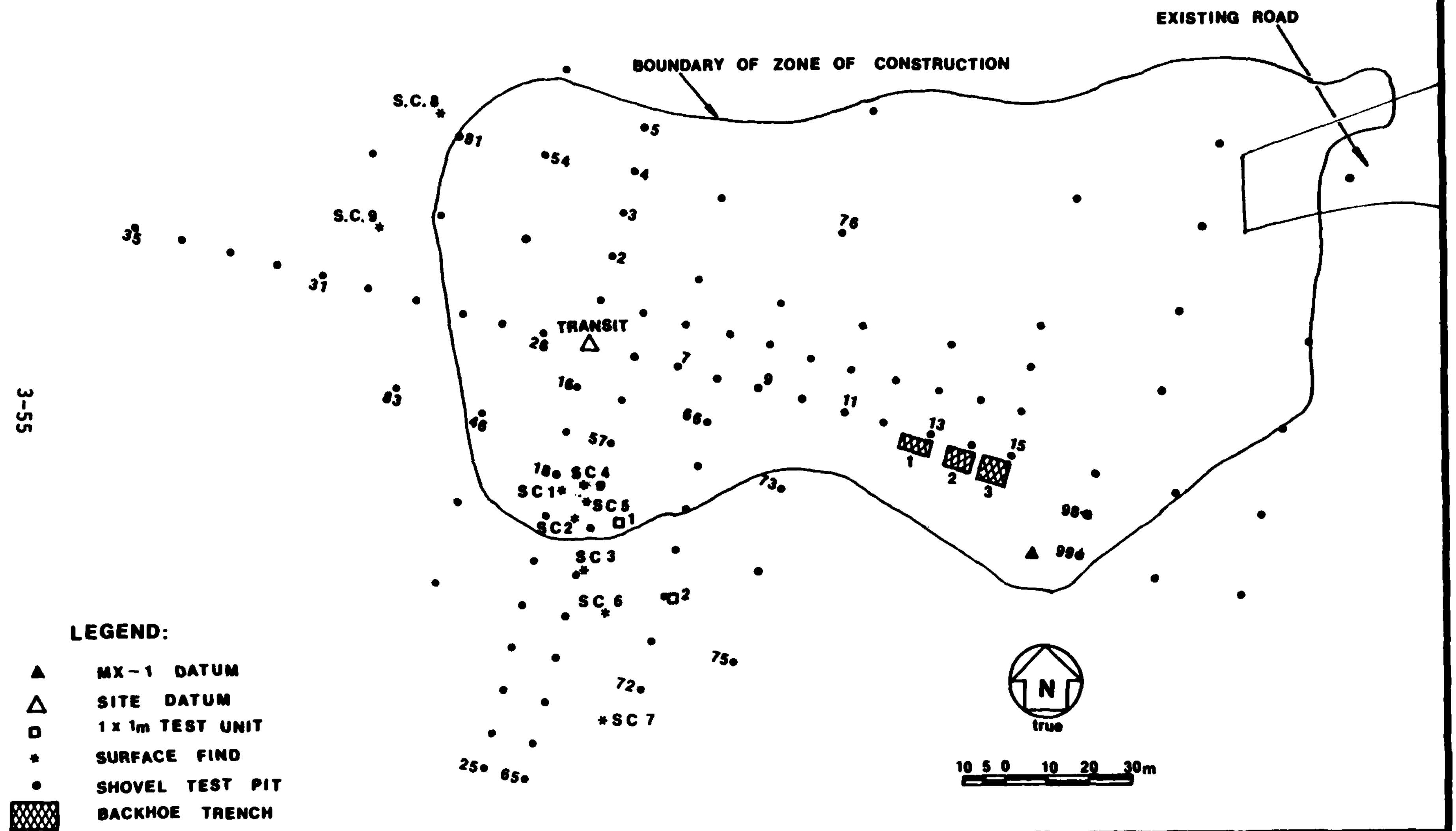

Figure 3-11. SBa-1155 (TP-1).

SBa-1181 (Figure 3-12)

Immediate Environmental Context: The site, now destroyed, was located on an intermediate dune ridge approximately 300 m east-northeast of SBa-1155. Soils are loose dune sands semi-stabilized by coastal sage scrub.

Gross Site Characteristics: HDR describes SBa-1181 as a low density deposit of Monterey chert flakes buried under 1 or 2 feet of dune soil. A small leaf-shaped projectile point was found in the vicinity of the site (in addition to the materials described above).

Nature of the Investigations: Limited testing of the site was undertaken by HDR in September 1980. Their work involved the excavation of eight judgmentally placed STPs excavated to a maximum depth of 80 cm and a controlled collection of materials exposed on the surface. A total of four tools (three bifaces and a core) and 29 chipped stone flakes were recovered by both HDR and VTN.

Missile Assembly Building (MAB)

The MAB, to be used for final missile assembly, is situated within the central portion of the stabilized dunes of the San Antonio Terrace. The facility is sited south and east of the western shelter area, and north and west of the eastern shelters. The structure occupies approximately 27,600 m^2 on what was a prominent southeasterly trending dune. Access roads connecting the MAB to the western shelter facilities (discussed in a preceding section of this chapter) and to a nearby road have been constructed. Design plans for the eastern shelter access roads have been abandoned.

HDR initially surveyed the construction zone of the MAB and the proposed access route to a nearby road in the fall of 1979. The proposed facility location was surveyed in 10 m to 20 m interval transects along the long axis of the dune. A corridor 60 m wide was surveyed along the access road alignment in 10 m interval transects. Because dense vegetation was encountered within areas where the road corridor passed through dune swales, the access route was surveyed twice.

One wind polished flake was found in an isolated context on the south side of the dune. No other remains were located during HDR's field reconnaissance and the area was cleared for construction.

Construction of the MAB was monitored by VTN archaeologists during the summer of 1980. Four archaeological sites (SBa-1170, -1173, -1176 and -1177) and several loci of isolated finds were discovered by VTN monitors during the initial construction grading of the MAB and its associated access road. Subsequent investigations of these resources were undertaken by HDR in September 1980 and by UCSB-OPA (under contract to HDR) in June and July 1980. Site descriptions and a discussion of the archaeological investigations undertaken at each of these sites are provided below.

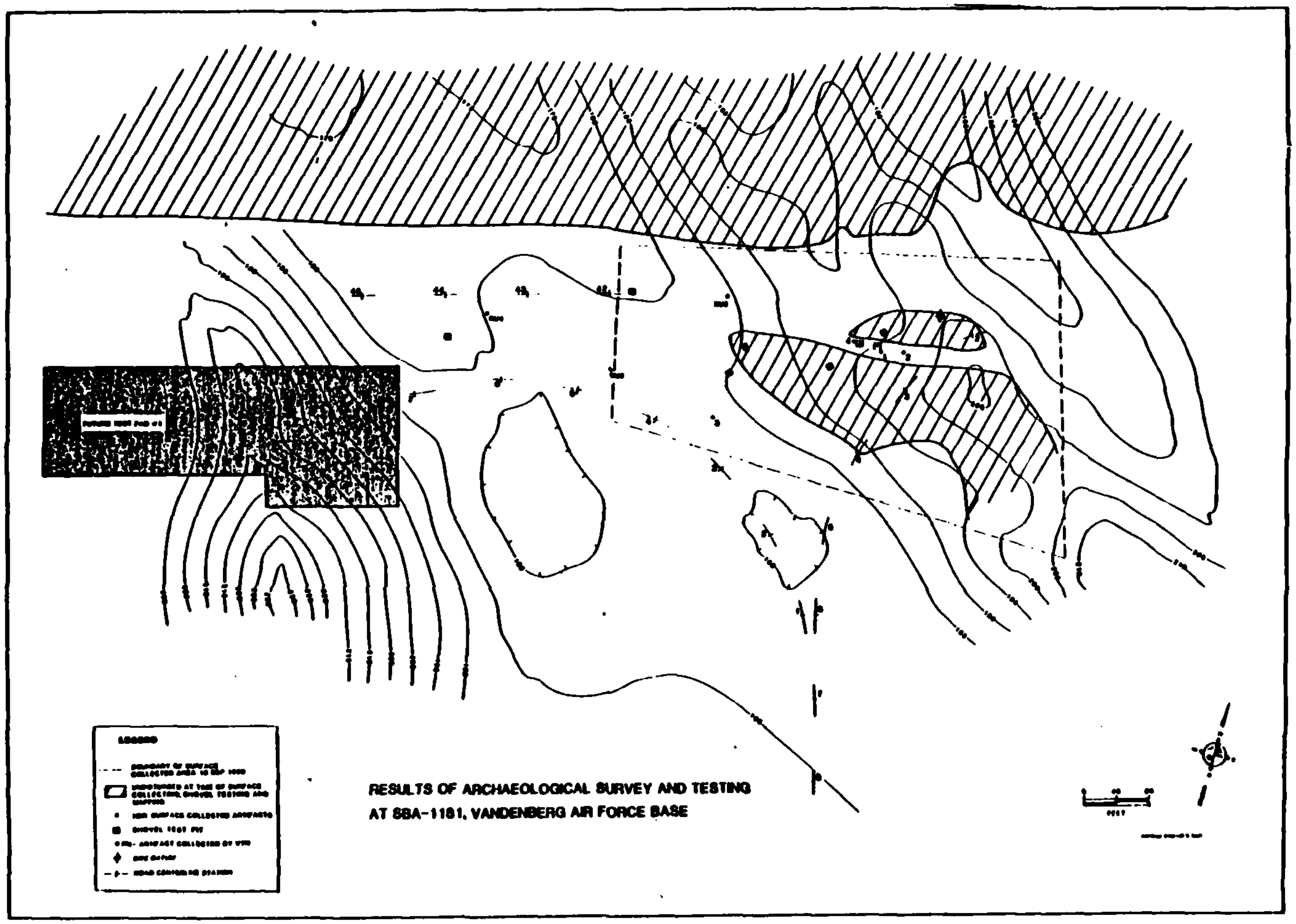

Figure 3-12. Results of Archaeological Survey and Testing at SBa-1181 (HDR Map).

Immediate Environmental Context: With the exception of SBa-1179 (located within a dune swale), the sites were situated on dune ridges. The dune ridge soils are characterized by loose dune sand semi-stabilized by coastal sage scrub. The soil at SBa-1170 was described by HDR as slightly compact dark brown, silty sand which probably corresponds to the Casmalia Surface described by Johnson in Chapter 4. Coastal sage scrub is also predominant at SBa-1170.

SBa-1170 (Figure 3-13)

Gross Site Characteristics: SBa-1170 was recorded by UCSB-OPA as a medium density lithic scatter of chert chipped stone flakes and chunks. The site measured 180 m x 120 m and had a depth of at least 160 cm. The major constituents are described as chert flakes and a high percentage of heat treated shatter.

Nature of Investigations: SBa-1170 was found by VTN monitors during grading of the MAB site. Subsequent work by UCSB-OPA involved controlled surface collection within the impacted area and the placement of 10 controlled STPs, excavated in 20 cm levels to 100 cm, along transects, intersecting the site datum, running north-south and east-west. In addition, three controlled test units (one 1 m x 2 m and two 1 m x 1 m) were excavated in 20 cm levels to maximum depths of 100 cm. STPs were excavated in the bottom of each unit to depths varying between 126 cm and 160 cm at which point water was hit. Two of the test units were placed on the periphery of the surface scatter and one was placed within the scatter. Both STP and test unit soils were screened through 1/8 inch mesh.

Material recovered from SBa-1170 includes 959 chipped stone flakes and 10 chipped stone tools including 2 projectile points (one with a contracting stem). Bone and carbon were also recovered. Soil samples were processed by CCP's Santa Barbara Laboratory. Because of the high water table, the maximum depth of the deposit was not determined. The proposed FOCL cable system (discussed in a succeeding section of this chapter) was routed through the vicinity of SBa-1170. In November 1981 (after completion of the MAB and access roads), CCP excavated six STPs at 50 m intervals along the FOCL alignment in the vicinity of SBa-1170. The STPs were excavated in a single level to a depth of 50 cm and soils were screened through 1/8 inch mesh. The STPs were devoid of cultural material and only one utilized chert flake was recovered from the surface.

SBa-1173 (Figure 3-14)

Gross Site Characteristics: HDR describes SBa-1173 as a moderate density scatter of small wind polished chipped stone debitage deposited in 2 loci over an area of 1,000 m^2. The deposit appears to be concentrated at 40 cm to 60 cm. Small chipped stone flakes were sparsely distributed to about 100 cm. One isolated projectile point fragment was collected in the vicinity of SBa-1173, but north of the site.

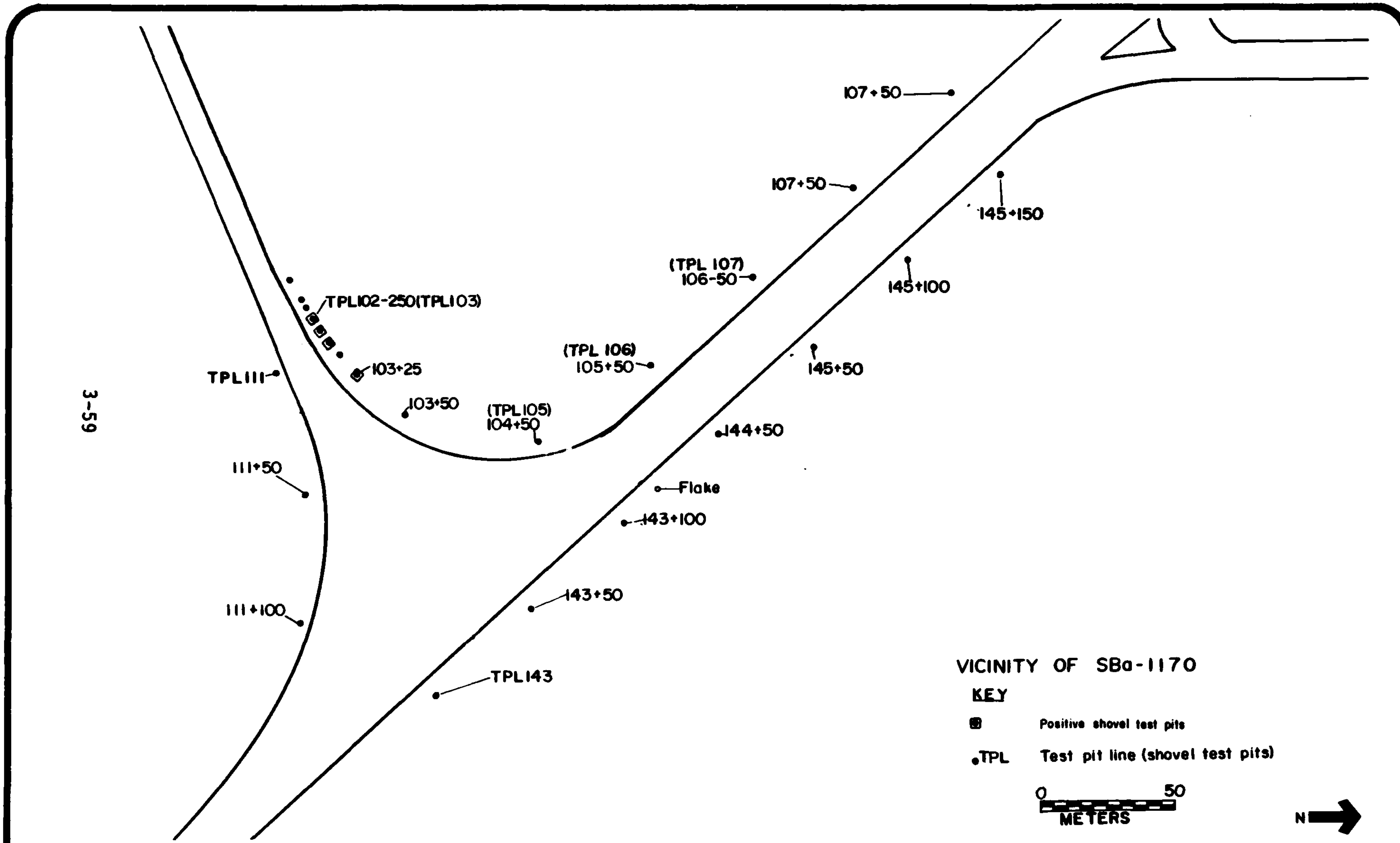

Figure 3-13. SBa-1170.

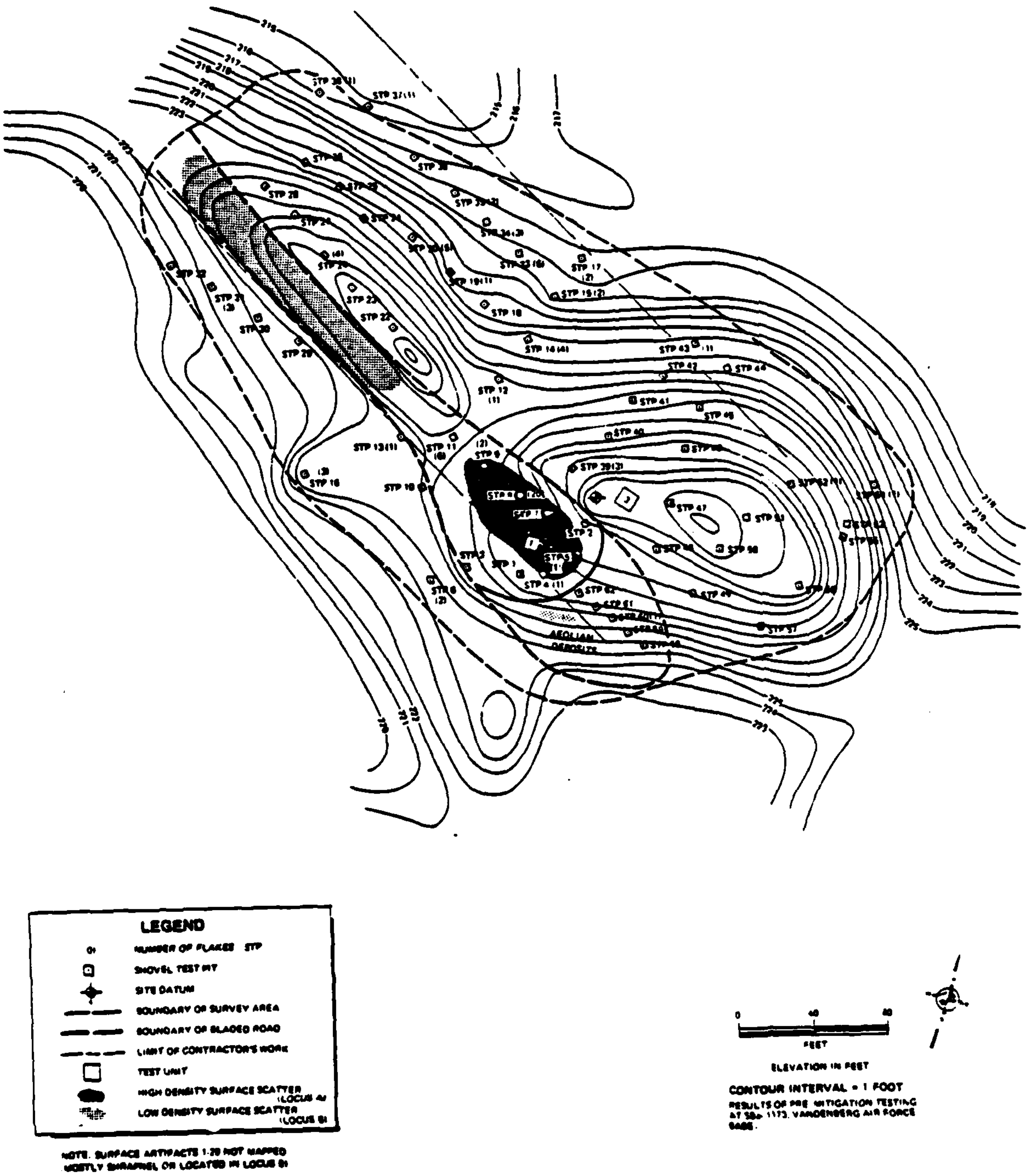

Figure 3-14. SBa-1173 (HDR Map).

Nature of Investigations: After the discovery of SBa-1173 by VTN monitors, HDR completed a controlled collection of the exposed surface materials and excavated two controlled test units in locus A. One 2 m x 2 m unit (Unit 1 excavated to 75 cm, STP in bottom of unit to 170 cm) was placed within the exposed scatter and a 3 m x 3 m (Unit 3, excavated to 50 cm, STP in bottom of unit to 115 cm) was placed in an undisturbed area adjacent to Unit 1. Both units were excavated in arbitrary 10 cm levels and screened through 1/16 inch mesh. Small chipped stone flakes were recovered from the upper 10 cm of Unit 1; Unit 3 contained no cultural material. Note: Unit 1 was partially excavated to 75 cm (2 m x 2 m to 35 cm, then 1 m x 2 m to 75 cm).

An additional unit (Unit 2) was to have been placed in locus B, but, based on the test results of Units 1 and 3, HDR decided rather to implement a large scale STP investigation to delimit the site boundaries. Sixty-two STPs were excavated to depths ranging from 25 cm to 115 cm at grid point intersections (intervals unknown) over the surface of the site. Small amounts of chipped stone flakes were recovered from the STP testing.

A total of 1,068 chipped stone flakes were recovered from SBa-1173. Of these, only 81 were 1/4 inch or larger. Sparse shell was also recovered. The majority of the material was recovered by VTN and HDR during surface collection. VTN monitors collected the only tool associated with SBa-1173, a projectile point found in an isolated context north of the site.

The revised 12.47 KV alignment passed through the vicinity of SBa-1173 after the completion of the MAB construction. No additional information could be located; however, the power pole emplacements were almost certainly monitored by VTN.

SBa-1173 was also encountered on the FOCL cable system alignment surveyed by CCP. Five STPs were excavated at 5 m and 10 m transect intervals in a single level to 50 cm. One small shell fragment and one chipped stone flake were recovered from two STPs. No additional cultural remains were encountered at SBa-1173.

SBa-1176

Gross Site Characteristics: SBa-1176 was a low density lithic scatter with concentrations of possibly wind-polished chipped stone flakes (loci A and B) deposited over an area approximately 70 m x 100 m. On discovery, the site was severely disturbed by MAB associated which exposed the site. Chipped stone flakes were encountered to 120 cm; most of this material was encountered in the upper 40 cm of the site.

Nature of the Investigations: HDR archaeologists surveyed the surface of the site and excavated nine judgementally placed STPs to a maximum depth of 60 cm. Subsequent work by UCSB-OPA was in the form of controlled surface collection, STP excavations, and test unit excavations. Early testing suggested that locus A was too badly disturbed to justify data recovery so these efforts were concentrated in locus B.

Surface collection was done by crew members spaced at 1 m intervals within a 9 m x 13 m area. Nineteen STPs were excavated to 60 cm along transects through the site.

Four 1 m x 1 m judgementally placed units were excavated in 20 cm levels to a depth of 80 cm. Unit size was changed in subsequent excavations to include 2 m x 2 m, 1 m x 2 m and 1 m x 1.5 m units. An additional seven units were excavated in 20 cm levels to depths varying between 40 cm and 120 cm comprising a total excavated volume of 14.6 m^3. All soils were screened through 1/8 inch mesh. A total of 658 chipped stone flakes was recovered from SBa-1176. Faunal remains are not present in the collections from this site.

The site is now destroyed.

SBa-1177 (Figure 3-15)

Gross Site Characteristics: SBa-1177 was a highly disturbed light scatter of debitage, shell, fire altered rock, utilized flakes and tools. The collection from this site includes five projectile points and two bifaces. The site measures 40 m x 50 m and seems to have had little depth. Two loci of relatively high density were noted during initial testing.

Description of Investigations: The site was discovered in late June 1980 by VTN monitors during grading of the road and parking lot for the MAB. HDR excavated nine STPs to depths which ranged from 30 cm to 60 cm. VTN, HDR and UCSB-OPA all conducted controlled surface collections at the site.

The initial testing at SBa-1177 was undertaken by HDR in June 1980. Nine STPs (approximately 1 m x 1 m in size) were excavated to depths ranging from 35 cm to 60 cm. The remainder of the subsurface testing was done by UCSB-OPA.

Work in locus A included two 2 m x 2 m test units excavated in 20 cm levels to depths of 80 cm and 100 cm and eight 5 m x 5 m surface scrapes to a depth of 10 cm. UCSB-OPA also excavated three STPs to a depth of 100 cm.

Investigation in locus B included additional two STPs excavated to 100 cm and two test units (one 1 m x 1 m to 30 cm and one 1 m x 2 m to 100 cm). STPs were excavated in the unit bottoms to respective depths of 100 cm and 140 cm below the surface. The total excavated volume of both loci was 32.7 m^3. All soils were screened through 1/8 inch mesh.

Unfortunately, the disturbance of the site by construction equipment precluded the collection of much contextual information. A total of 23 chipped stone flakes and seven tools (five projectile points and two bifaces) was recovered from the site. Shell and bone were also present in the collection.

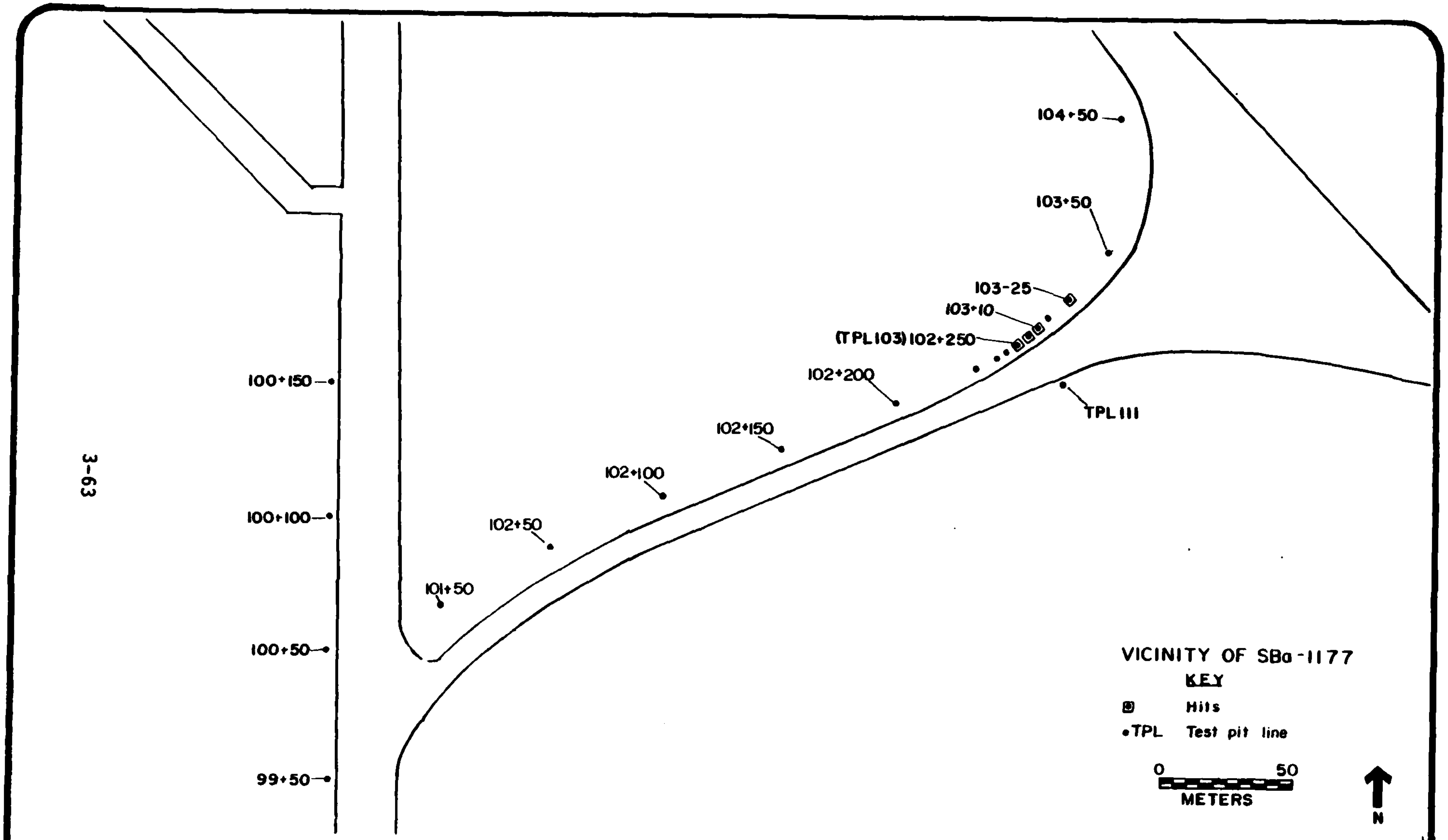

Figure 3-15. SBa-1177.

Gatehouse Project

Designed to improve access to the MX missile facilities located in the northern portion of VAFB, the Gatehouse project involved the widening and improvement of a road and the construction of a new gatehouse along that road at the base entrance. Site records indicated an existing archaeological site, SBa-1036 (recorded by Spanne in 1972) situated within the potential impact zones of the project. UCSB-OPA, under contract to HDR, undertook preliminary test and mitigation investigations at the site during the summer of 1980. A site description and discussion of UCSB-OPA's field investigations are provided below.

SBa-1036

Immediate Environmental Context: SBa-1036 is located along both sides of a road on an old dune surface. San Antonio Creek basin lies directly south and a small lake is adjacent to the site to the west. A eucalyptus windbreak is planted on the north side of the road. A remnant coastal sage scrub plant community is present but is being supplanted by introduced grasses and shrubs.

Gross Site Characteristics: The prehistoric portion of the site contains a centralized midden deposit surrounded by widely scattered lithics. An historic component consists of an abandoned ballast railbed and associated artifacts (ties and spikes). Evidence of both components is present in the first 60 cm of the deposit while the prehistoric materials extend to a maximum depth of 180 cm.

Nature of the Investigation: The site was first recorded by Spanne in 1972. Subsequent investigations in 1980 were undertaken by UCSB-OPA (under contract to HDR) in five phases of work between May 1980 to September 1980.

The first phase of UCSB-OPA's work at SBa-1036 (HDR-II) involved an intensive 2 m interval transect survey of the site. In areas of poor surface visibility, surface vegetation was removed at 3 m intervals. A controlled surface collection was made of an area approximately 2730 m^2. Subsurface testing involved the excavation of 16 STPs to a depth of 50 cm and four 1 m x .05 m test units (two to 80 cm and two to 100 cm).

The second phase (HDR III) was undertaken in response to possible impacts from the proposed installation of a 12.47 KV power line along EL Rancho Road. An 8 m wide corridor along the proposed pole alignment was intensively surveyed and a controlled surface collection was made over an area of approximately 770 m x 7 m along the proposed alignment. Seven STPs (one to 40 cm, six to 100 cm) were excavated at the pole emplacement location along the proposed alignment.

As UCSB-OPA's preliminary testing of SBa-1036 indicated that the proposed gatehouse construction would impact the site, an alternative location for this structure on the eastern fringe of SBa-1036 was proposed. The alternative location was surveyed in 10 m interval transects during the third phase

(HDR IV) UCSB-OPA's investigation at SBa-1036. Thirteen STPs were excavated to a depth of 100 cm and two (1 m x .05 m and 1 m x .06 m) test units were excavated to a depth of 100 cm at the proposed location of the structure. STPs were placed in the bottom of each unit to a depth of 60 cm.

The four phases of the investigation (HDR-V) was undertaken to define the scope of the mitigation required at SBa-1036 prior to the gate house construction. Two 1 m x 2 m test units were excavated to a depth of 160 cm and shovel tested to a maximum depth of 220 cm. The maximum depth of the deposit was determined to be 180 cm.

The final mitigation of the proposed gate house impacts constituted the fifth and final phase of UCSB-OPA investigation of SBa-1036. Three 1 m x 2 m controlled test units were excavated to depths of 160 cm (two) and 200 cm (one). The investigation revealed a mix of historic and prehistoric materials in the first 40 to 60 cm of the deposit. A medium density lithic scatter, associated with the major midden area north of the construction zone, was found to extent to 180 cm below the surface.

Test units in all phases of work at SBa-1036 were excavated in 20 cm levels and soils were screened through 1/8 inch mesh. A total volume of 21.5 m^3 was excavated from the site. A total of 993 chipped flakes were recovered from SBa-1036. Chipped stone materials also include four core and two bifaces. Shell, bone, and carbon are present in the collections. Column, soil and flotation samples were processed by CCP's Santa Barbara laboratory. In spite of the several investigations conducted at this site, its research potential has not been exhausted.

Soil Borrow Areas

Several borrow areas were considered as locations to provide borrow soils for the MX missile facilities. Archaeological and biological constraints, however, as well as the lack of suitable soils in the vicinity of the San Antonio Terrace, determined that all borrow soils will be obtained from an off base location.

The initial borrow area was surveyed by HDR archaeologists in 5 m to 10 m transect intervals within an area of dense vegetation in the higher elevations of the landform; this area was considered by HDR to be archaeologically sensitive. The remainder of the borrow area was surface inspected at transect intervals of 15 m to 20 m.

As anticipated, an archaeological site was discovered within the sensitive area; it was recorded as SBa-1565. This site has been discussed in a previous section (12.47 KV power line) and therefore will not be included in this section.

Three additional locations, all on gently south sloping landforms above San Antonio Creek, were considered for potential borrow areas. These areas (also considered archaeologically sensitive) were not systematically surveyed by HDR, but were briefly checked to determine the presence or absence of archaeological sites. HDR's field checks resulted in the identification of

portions of a previously recorded site (SBa-1060) in proposed borrow Area 2 and two previously recorded sites (SBa-1033 and -1034) in proposed borrow Area 3. HDR did not record any archaeological remains in borrow Area 3; it is possible that the field check missed sites.

As no impacts to SBa-1033 and -1034 were anticipated from either soil borrowing or other MX related construction projects, further archaeological investigations were not undertaken at these sites. Site descriptions are provided below. Additional investigations were carried out on SBa-1060 in support of the 12.47 KV power line are discussed in a preceding section of this chapter and will not be included here.

SBa-1033

Immediate Environmental Context: The site is situated on a hilltop located on the north flank of San Antonio Canyon. A perennial spring is situated about 240 m west of the site. Vegetation consists of light brush and introduced grasses with sage scrub and riparian species in adjacent areas. Site soils are described as brown sand and surrounding soils as tan sand.

Gross Site Characteristics: Recorded by Spanne in 1972, SBa-1033 extends over an area of approximately 106 m x 100 m. The vertical dimensions have not been determined. Material observed on the surface include utilized chipped stone flakes and blades, weathered shell and burned bone. HDR noted three clusters of chipped stone debitage (loci A, B, and C) located north and east of the central deposit. With the exception of possible past cultivation, the site appears undisturbed. As no MX associated impacts are anticipated, SBa-1033 has not been tested.

SBa-1034

Immediate Environmental Context: The site is located on the north of flank of San Antonio Canyon. Vegetation consists of sage scrub with sage scrub, grassland, and riparian species in adjacent areas. Soils are described as tan sand.

Gross Site Characteristics: Recorded by Spanne in 1972, the site is described as a trace density of chipping waste and a few cracked cobble fragments scattered over an area 18 m in diameter. SBa-1034 has not been tested and appears to be undisturbed. It is not subject to any MX associated impacts.

Fiber Optics Cable System and Communication Line (Figures 3-16, 3-17, and 3-18)

This section describes the archaeological field reconnaissance conducted by CCP along the subsurface routes of the Fiber Optics Cable System and the Communication Line. Although these are separate systems, the cable routings, for the most part, followed the same course. Throughout this section, the term FOCL designates both projects. In those instances in which the routes are separated, FO represents the Fiber Optics Cable and CL designates the Communication Line.

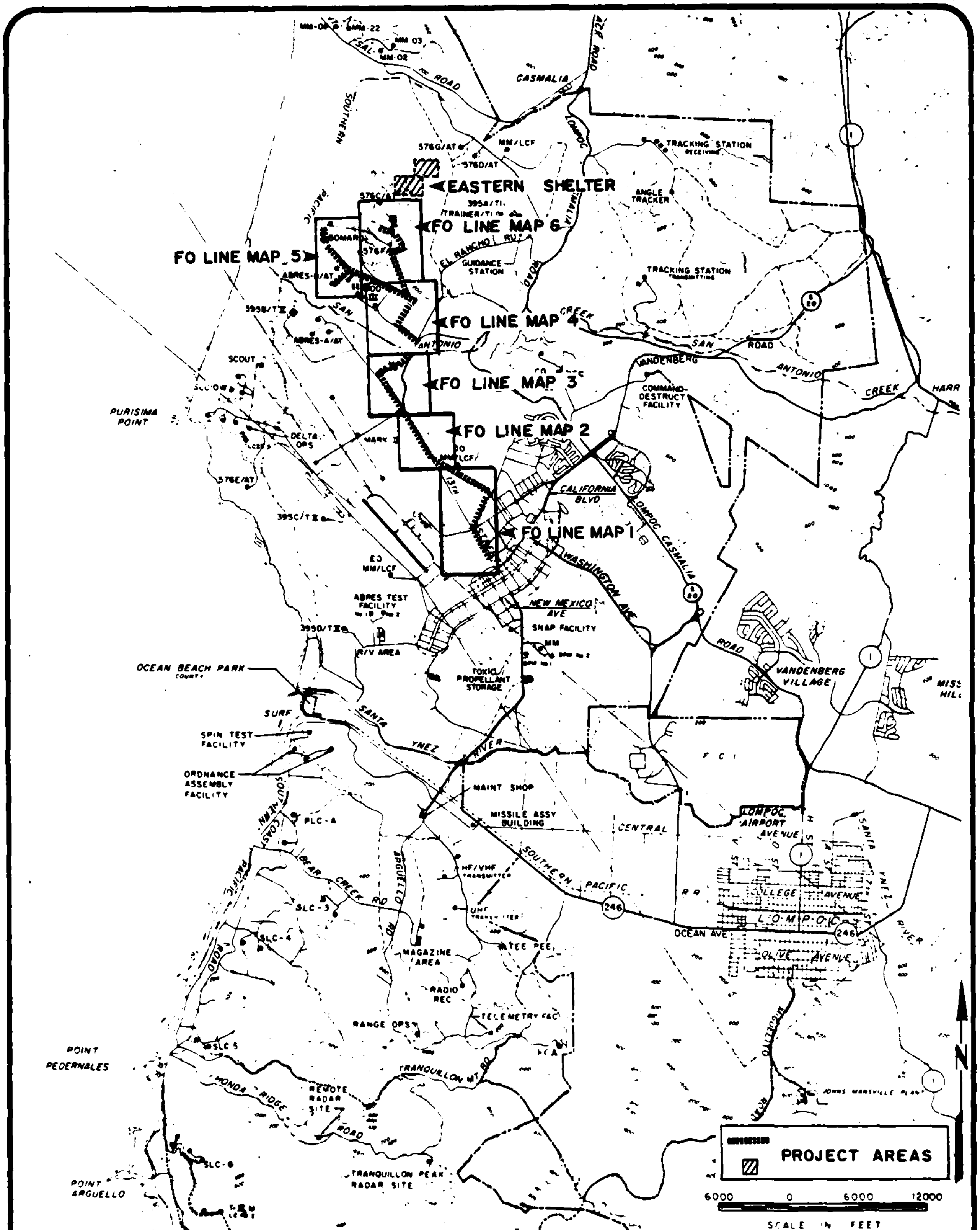

Figure 3-16. General Project Area Map Showing Route Surveyed During the Fiber Optics/Communication Line and Eastern Shelter Block Survey.

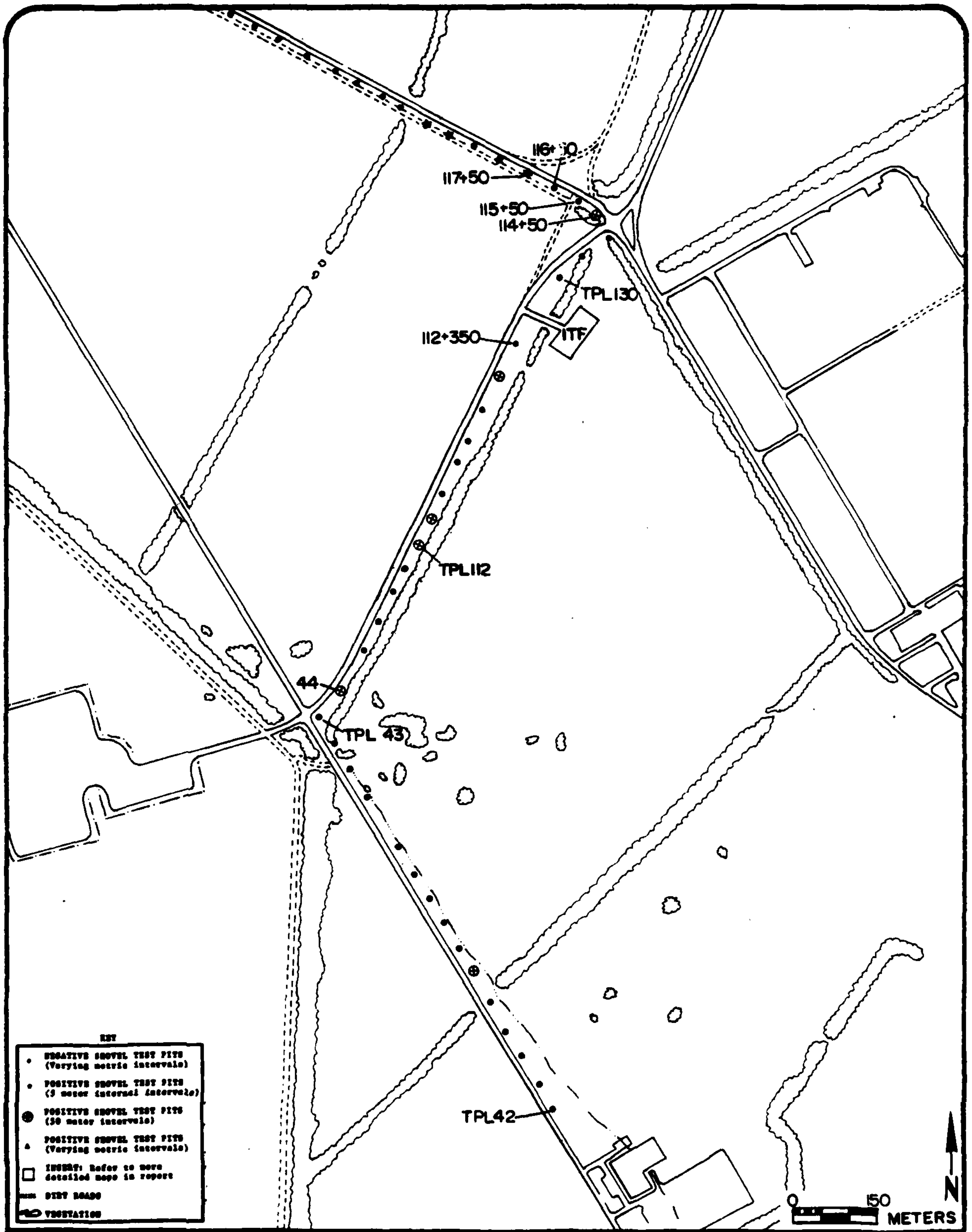

Figure 3-17. Southern Starting Point of the Fiber Optics/Communication Line Survey.

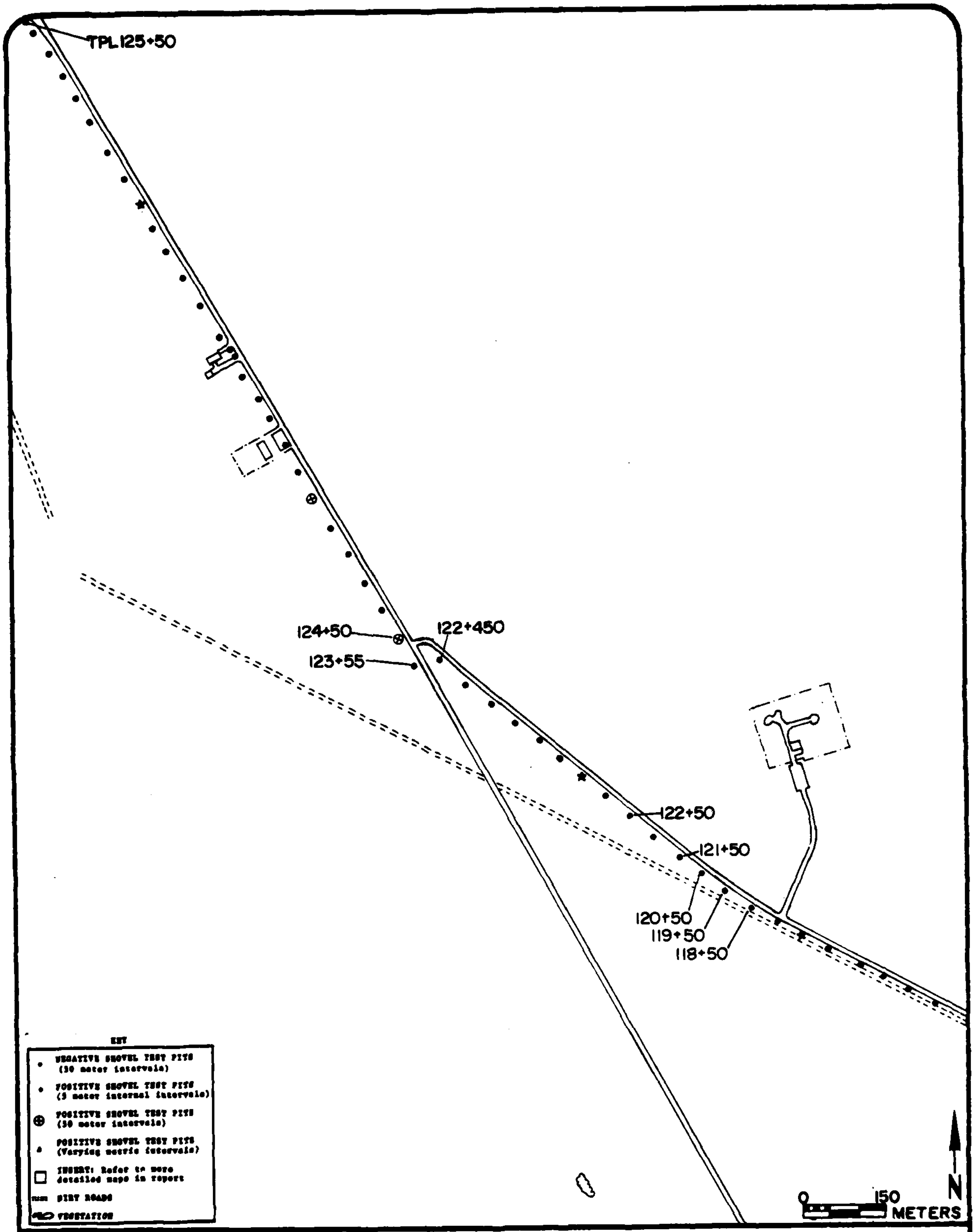

Figure 3-18a. Fiber Optics/Communication Line Survey (Part 1: Southernmost Segment).

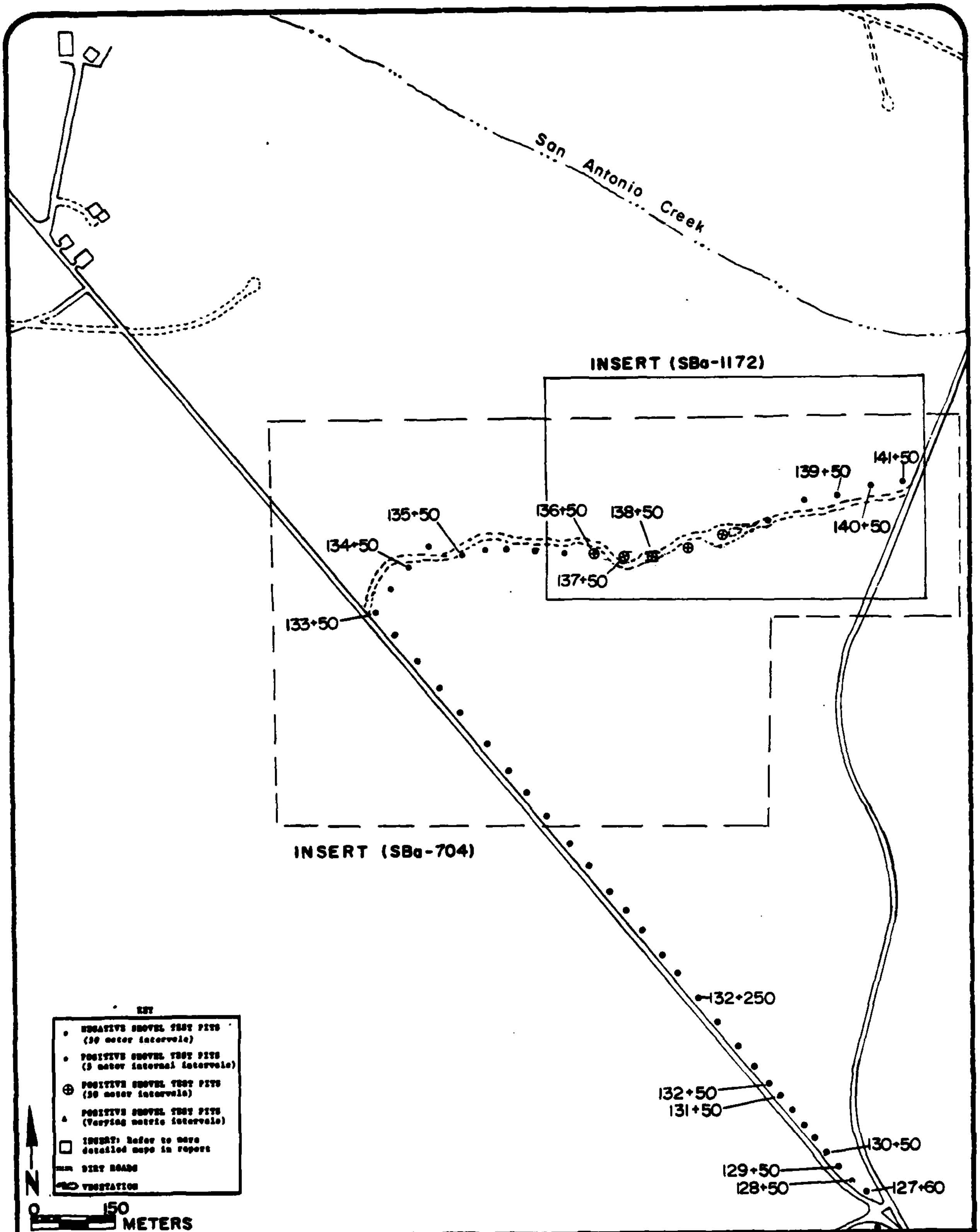

Figure 3-18b. Fiber Optics/Communication Line Survey (Part 2).

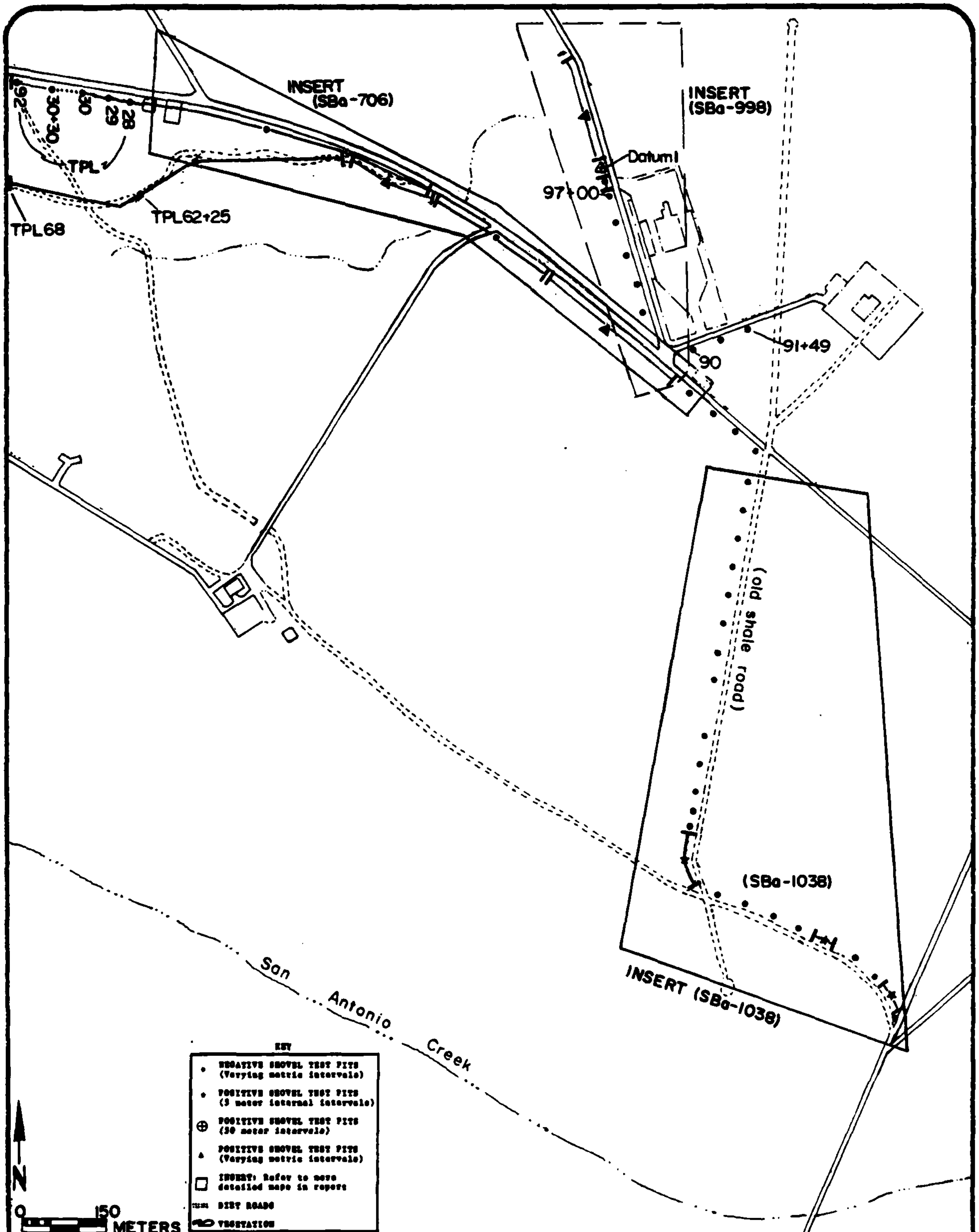

Figure 3-18c. Fiber Optics/Communication Line Survey (Part 3).

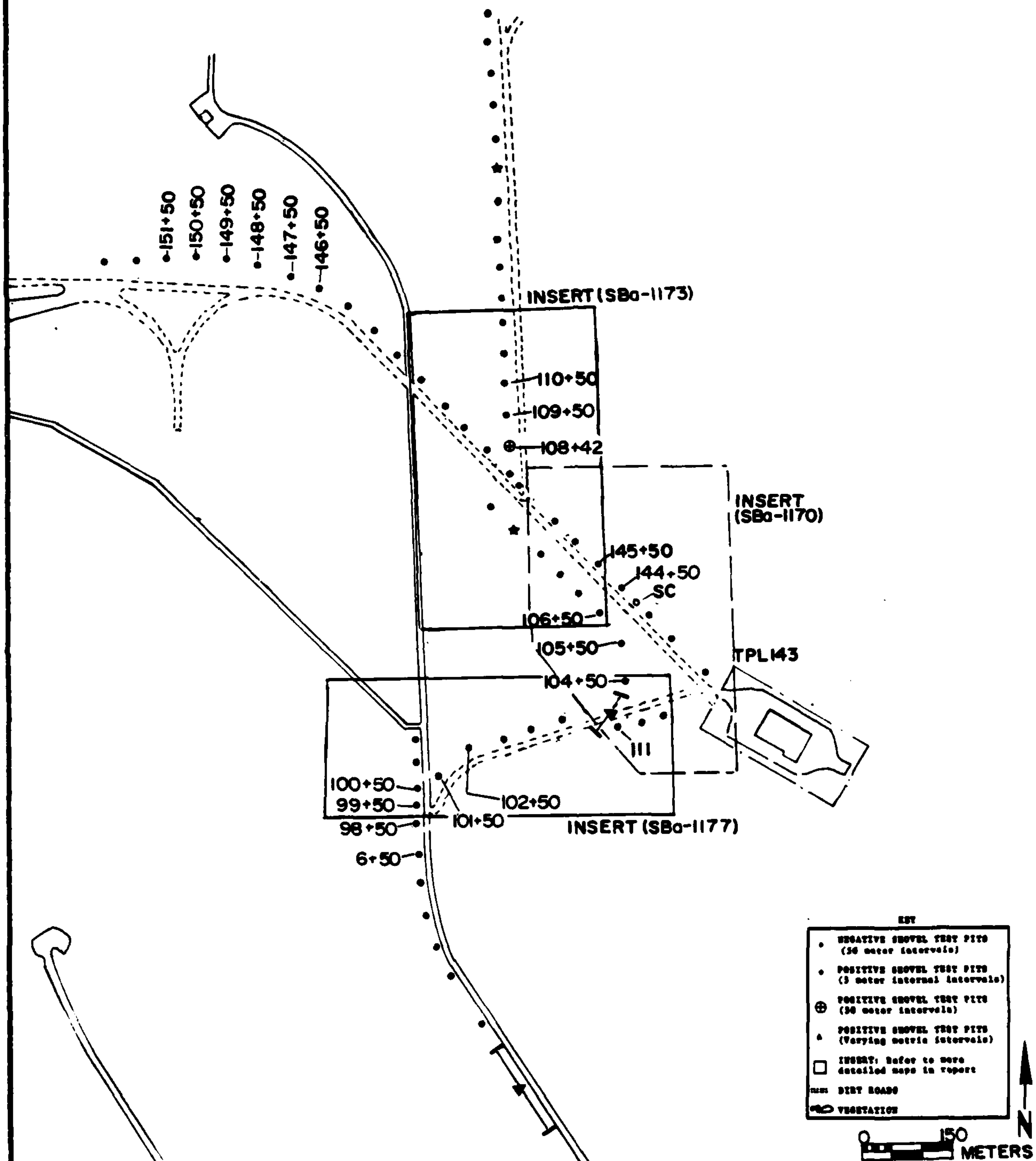

Figure 3-18d. Fiber Optics/Communication Line Survey (Part 4: Northernmost Segment).

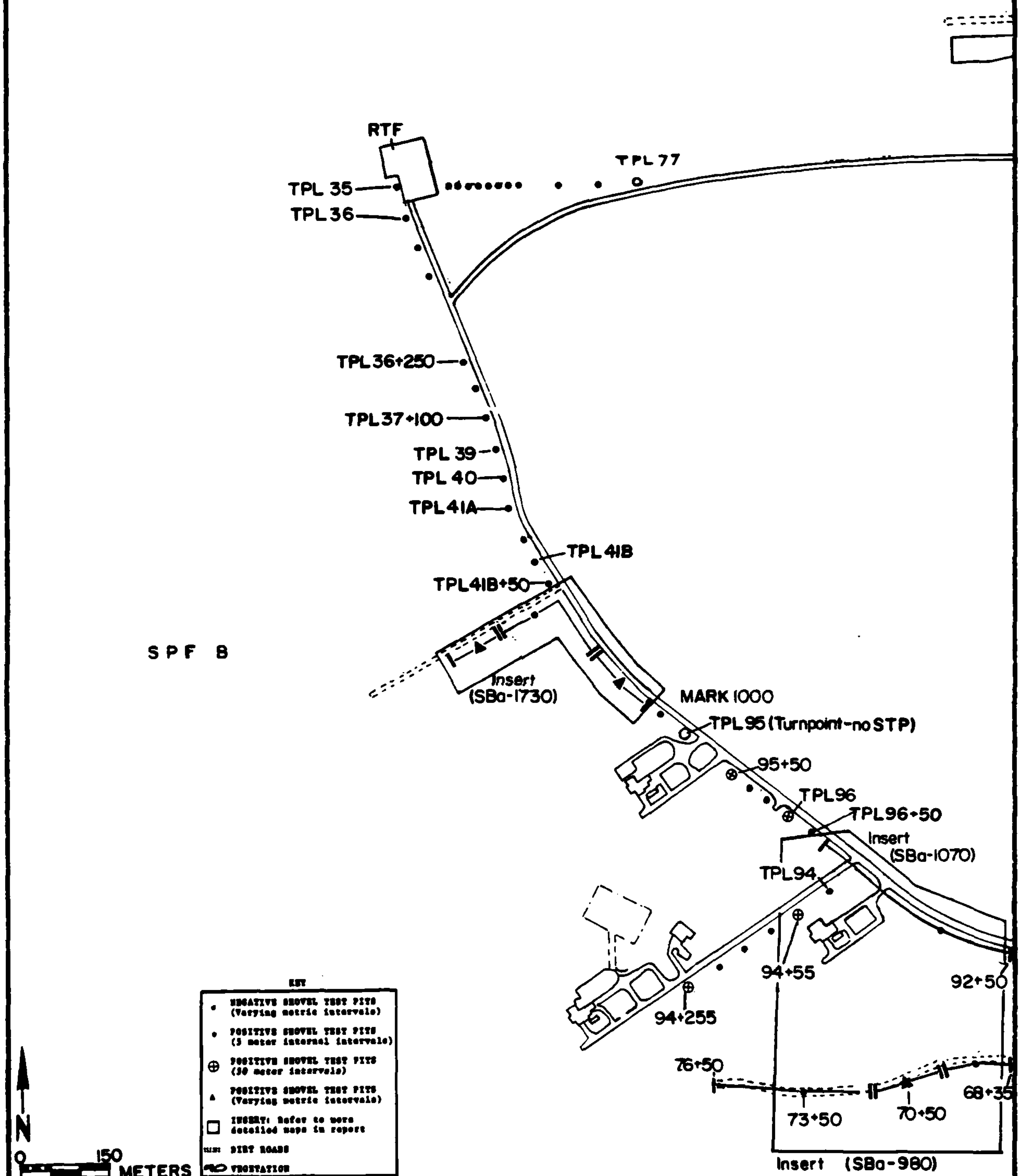

Figure 3-18e. Fiber Optics/Communication Line Survey (Part 5: Northwesternmost Segment).

Situated primarily in the San Antonio Terrace (the southernmost extension of the FOCL is south of San Antonio Creek on Burton Mesa outside of the San Antonio Terrace area), the FOCL extends for a distance of approximately 17 km. Generally following existing road alignments, the subsurface portions of the cables were buried by either plowing in or by trenching within a 20 m wide corridor along the side of the road.

Field work was accomplished during the months of August, September, October, and November 1981. Survey and testing of the FOCL cable routes included six stages: surface reconnaissance, systematic subsurface survey, tests for isolation, site boundary definition, site testing, and monitoring.

The cable routes were not staked prior to the survey nor were the maps provided to CCP by the COE detailed enough to illustrate the exact placement of the cables. In response, survey crews were instructed to examine a corridor extending 20 m from the shoulder of the side of the road on which the cable would be buried. Where it was indicated by maps or COE personnel that the cable routes varied beyond this 20 m corridor, the survey course, still 20 m wide, was centered on the indicated alignment. The surface of the survey corridor was carefully examined by crew numbers along transects spaced at 5 m intervals.

The FOCL alignments through all of SBa-998 and a portion of SBa-706 were surveyed using STPs at 5 m intervals. It became evident that although site boundaries were being well-defined, too little information was being gained concerning the sites to justify the continuation of this survey method. Further, the purpose of the survey was to discover archaeological resources, not to test previously known deposits. Based upon these considerations, a fixed spacing of 50 m for the placement of STPs along the cable routes was adopted as the appropriate subsurface survey procedure. Where cultural indicators were observed upon the surface or recovered from an STP, tests for isolation or boundary definition procedures were implemented.

The FOCL survey resulted in the discovery of one previously unrecorded archaeological site (SBa-1730). In addition, the site boundaries of SBa-706, -980, -998, and -1038 were redefined and in most cases significantly expanded. Information was also obtained on the horizontal distribution of intersite materials.

Limited information was obtained from SBa-704 (only five STPs were excavated) and only a few chipped stone flakes were retrieved from the vicinities of SBa-1170, -1173 and -1177, the latter two of which had been destroyed by the MAB construction. These three sites were not boundary tested. STPs excavated along the survey routes in the vicinity of SBa-1172 and -1709H were devoid of cultural materials.

Isolated occurrences were rarely found, although several tests for isolation were undertaken. Two isolates were recorded in close proximity to SBa-1177. Two additional isolates were discovered in the general vicinity of the intersection of two roads and the southeast boundary of SBa-1730.

Monitoring of the FOCL cable installations was accomplished by both CCP and VTN monitoring crews. In addition to plow-in and trench installation, splicing pits were excavated at several locations along the cable routes. CCP personnel monitored the plow-in installation of the CL cable along one road and the excavation of the cable trench through SBa-706. The remainder of the FOCL cable installation was monitored by VTN crews under direction of L. Spanne.

SBa-704 (Figure 3-19)

The FO route passed directly through SBa-704. The cable was laid in a trench approximately 90 cm deep and 30 cm wide. Prior to these impacts surface and subsurface survey was undertaken.

The site is located on the northern edge of Burton Mesa overlooking San Antonio Creek 500 m north and the San Antonio Terrace beyond. Site soils are very sandy and moderately well-developed. Chaparral and grasses afford dense vegetative ground cover.

Gross Site Characteristics: The site is approximately 200 m east-west by 120 m north-south. Depth is undetermined, although Spanne estimates it at a "probable" 30 cm to 60 cm. It consists of a moderately dense lithic scatter at which Spanne found 20 cores, 2 bifaces, and hammerstones; they were not collected. He mentions a "probable quarry" but CCP did not observe evidence of a quarry during examination of the impact corridor. It should be noted that SBa-1172 is located within 300 m of SBa-704 and was recorded as a probable quarry site by HDR archaeologists.

Description of the Investigations: The site was recorded initially by Spanne during UCSB's 1971 to 1973 survey of VAFB. HDR reexamined the site in 1980 and confirmed Spanne's description and boundaries. CCP's investigation of the site involved surface walkover of the 20 m wide FO corridor at 5 m intervals and the excavation of five STPs (maximum depth, 50 cm) at 50 m intervals; lithic and bone materials were recovered. As CCP's survey confirmed the results of both prior surveys, no further work was undertaken and the monitored installation of the FO cable proceeded.

VTN monitored the installation of the cable and the excavation of one 1 m x 2 m splicing pit in the northeast end of the site. VTN monitors screened a portion of the backdirt from the splice pit. A total of two tools, 52 flakes, plus the bone and concretions mentioned above were recovered by CCP and VTN.

SBa-706 (Figure 3-20)

Both the Fiber Optic and the Communications Line passed through SBa-706. The CL installation impacted the site along the south side of a road as did the FO line east of the intersection of two roads. From this intersection westward, the FO line followed the center of one of those roads past the western boundary of the site.

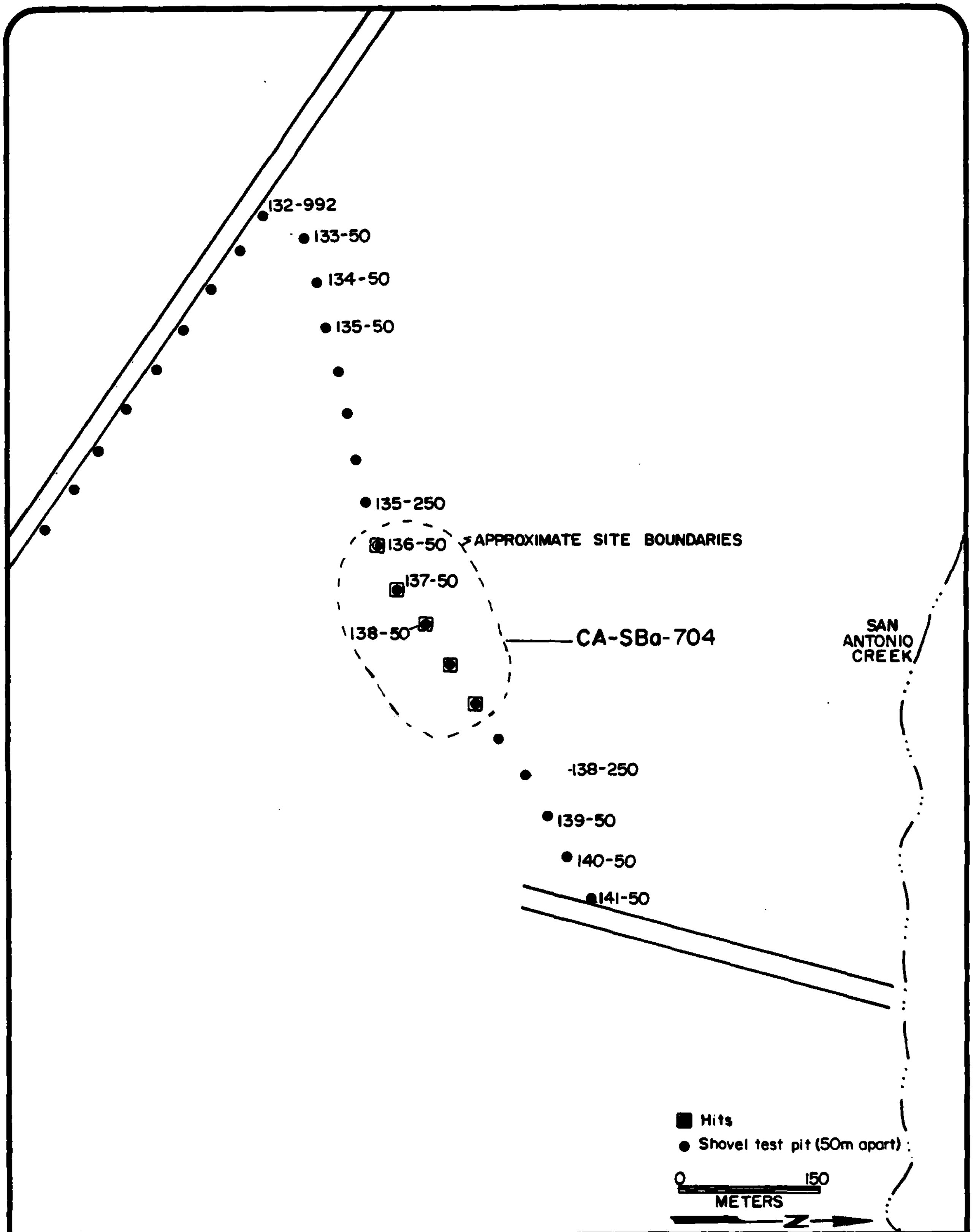

Figure 3-19. SBa-704.

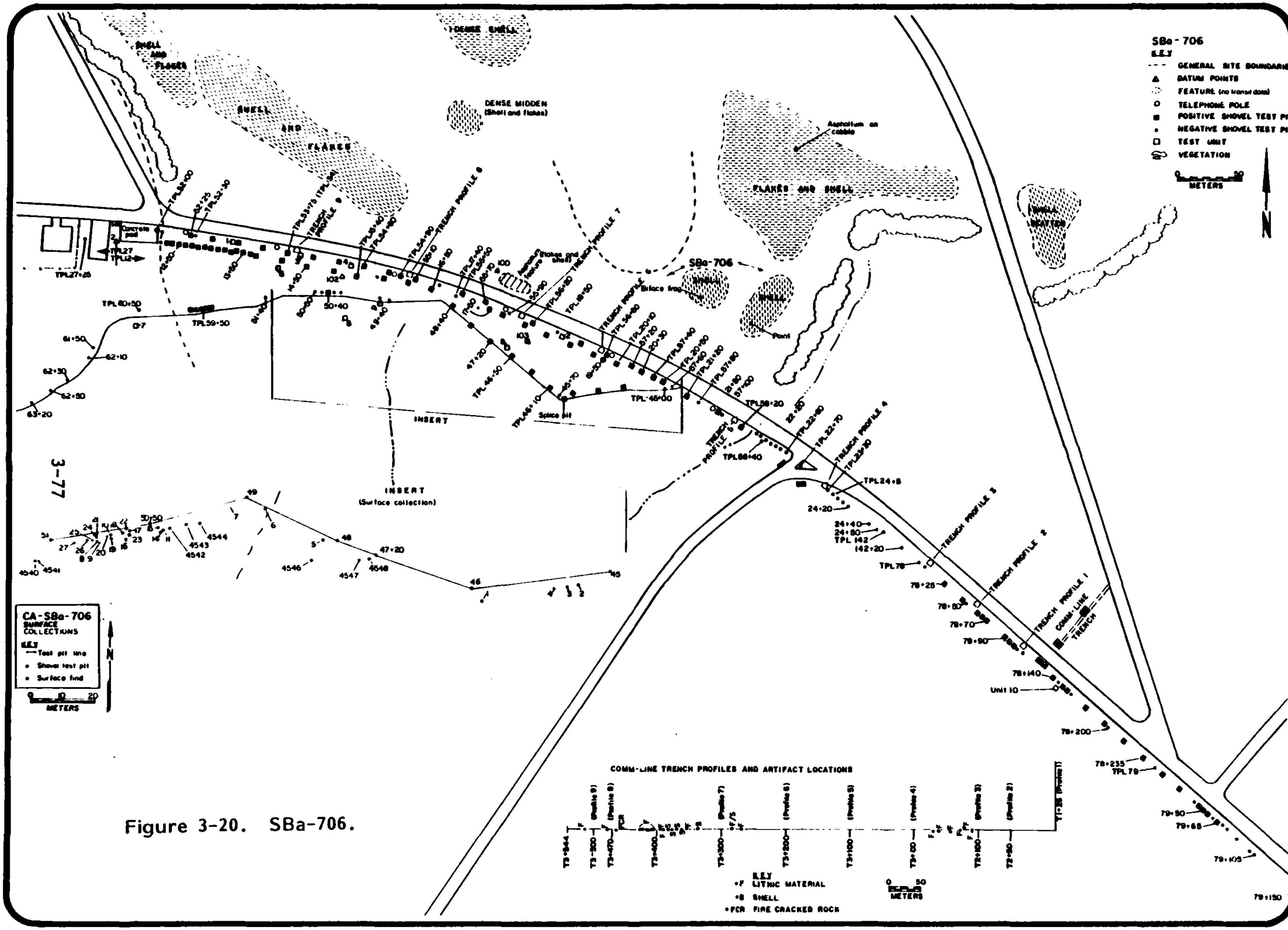

Figure 3-20. SBa-706.

Additional work was authorized by the COE after the CL installation contractor did considerable damage to the site when backfilling the trench with a large bulldozer.

Immediate Environmental Context: SBa-706 is located approximately 3 km inland of the Pacific Ocean and about 1 km north of San Antonio Creek within the south central portion of the San Antonio Terrace. Situated at what appears to be the leading edge of the intermediate dunes, field observations suggest that SBa-706 contains two depositional surfaces, the younger formed by the more recent dune advancement, and the older resulting from an earlier episode. Although both of these surface horizons contain relatively intact archaeological deposits, determination of age difference is not possible on the basis of available data.

The site's vegetation is varied as a result of intrasite soil differences, the effects of road construction, and the intentional planting of eucalyptus trees as windbreaks by local ranchers at the turn of the century. North of one of those roads the matrix is recent dune sand which supports typical dune scrub. A row of mature eucalyptus stands between two roads, with an understory of smaller eucalyptus and chaparral. South of one of those roads chaparral and dense grasses predominate on older well-developed dune derived soils.

Gross Site Characteristics: Spanne, who recorded SBa-706 in 1971, estimated that it covered an area approximately 280 m x 440 m on both the north and south sides of a road. As a result of the FOCL survey, the site boundaries have been expanded significantly to approximately 365 m x 485 m. The depth is estimated in excess of 1 m in some areas. Survey data indicate contiguous boundaries with SBa-1070, -1070E, and -1071 to the north and -998 to the east. The area including all of these sites is characterized by discrete deposits of shell midden with low density cultural materials interspersed between the midden deposits. Surface features include globules of asphaltum found in association with fire altered rock. Over 1,700 chipped stone flakes, 14 tools, and bone and shell materials were recovered.

Description of Investigations: In addition to CCP's investigations at SBa-706, three cultural resource surveys were conducted within the area of the site during the previous decade. The site was discovered and recorded by L. Spanne during the Cultural Resource Inventory of Vandenberg undertaken by UCSB (Spanne 1971; 1974). An additional survey of the site was made in 1979 by HDR in conjunction with anticipated widening of one road, and a portion of the site was also surveyed by WESTEC in 1981. None of these surveys involved any surface collection, nor was any subsurface testing accomplished. Additional investigations will be required to accurately define the boundaries and to determine the nature of the sursurface deposit.

The FOCL cable routing plans called for the parallel installation of both systems along the south side of a road within five feet of the hard shoulder, to the intersection of another road and then along the latter road to SPF-A. The CL line was laid and buried before the FO line, leaving no room for further ditching; as a result, it was decided to plow in the FO cable in the middle of the road to SPF-A.

STPs to a maximum depth of 50 cm were placed initially at 5 m intervals in the FOCL alignment along the first road. Of the 132 STPs excavated within SBa-706, 16 were placed at this 5 m interval. While the use of these close intervals clearly defined the western boundary of the site, it became evident that not enough archaeological information was being gained to justify the continuation of this survey method, and the southern and eastern boundaries of the site were therefore defined using less intensive procedures. While STP data appear to indicate that the southeastern boundary of SBa-706 lies north of the intersection of two roads, surface indicators and materials observed in the excavated cable trench indicate that the site boundary extends southeast to the general vicinity of yet another intersection.

Enough data had been obtained from the survey phase of the investigation to allow the determination of the estimates horizontal extent of the site along the impact corridors; the vertical extent was not known, given that the STPs were to only 50 cm. The trenching and plowing proceeded with a reasonable certainty that no features would be disturbed.

CCP's mitigation of impacts as the result of the installation of the FOCL lines at SBa-706 included the excavation of ten 1 x 1 m test units and a partial surface collection in addition to monitoring the cable installations. Three of the test units were excavated to a depth of 80 cm, six to 100 cm, and one to 160 cm. Three test units were excavated to mitigate impacts to the site in the originally surveyed corridor. In response to major unforeseen impacts from bulldozing within the corridor for backfilling of the CO line trench, six additional test units were excavated. The mitigation of impacts of the installation of the FO line along Bass Road involved one test unit. The project was redesigned to minimize construction disturbance.

CCP monitoring of the CL cable involved several operations. First, the ditching machine was followed and the backdirt quickly checked for indications of a buried feature or other unexpected cultural deposits. Next, an unsystematic sample of the excavated soil was screened. Any cultural material recovered was provenienced, given a lot number, bagged, and sent to the field laboratory for processing. Finally, profiles of 1 m long segments of the north wall of the trench were drawn at 100 m intervals, and soil samples were taken in 10 cm increments (from the top of the trench to the bottom) at these locations. VTN monitored in this area in December 1981, observing chipped stone flakes, fire-affected rocks, shell and bone.

<u>SBa-980 (Figure 3-21)</u>

The fiber optics line passed through SBa-980 200 m northwest of Bass Lake.

<u>Immediate Environmental Context</u>: SBa-980 is situated on the leading edge of the intermediate dunes. Soils are dune sand displaying little soil development. Vegetation is coastal dune scrub with wetland species at Bass Lake and at a wetland 100 m north of the site's western boundary.

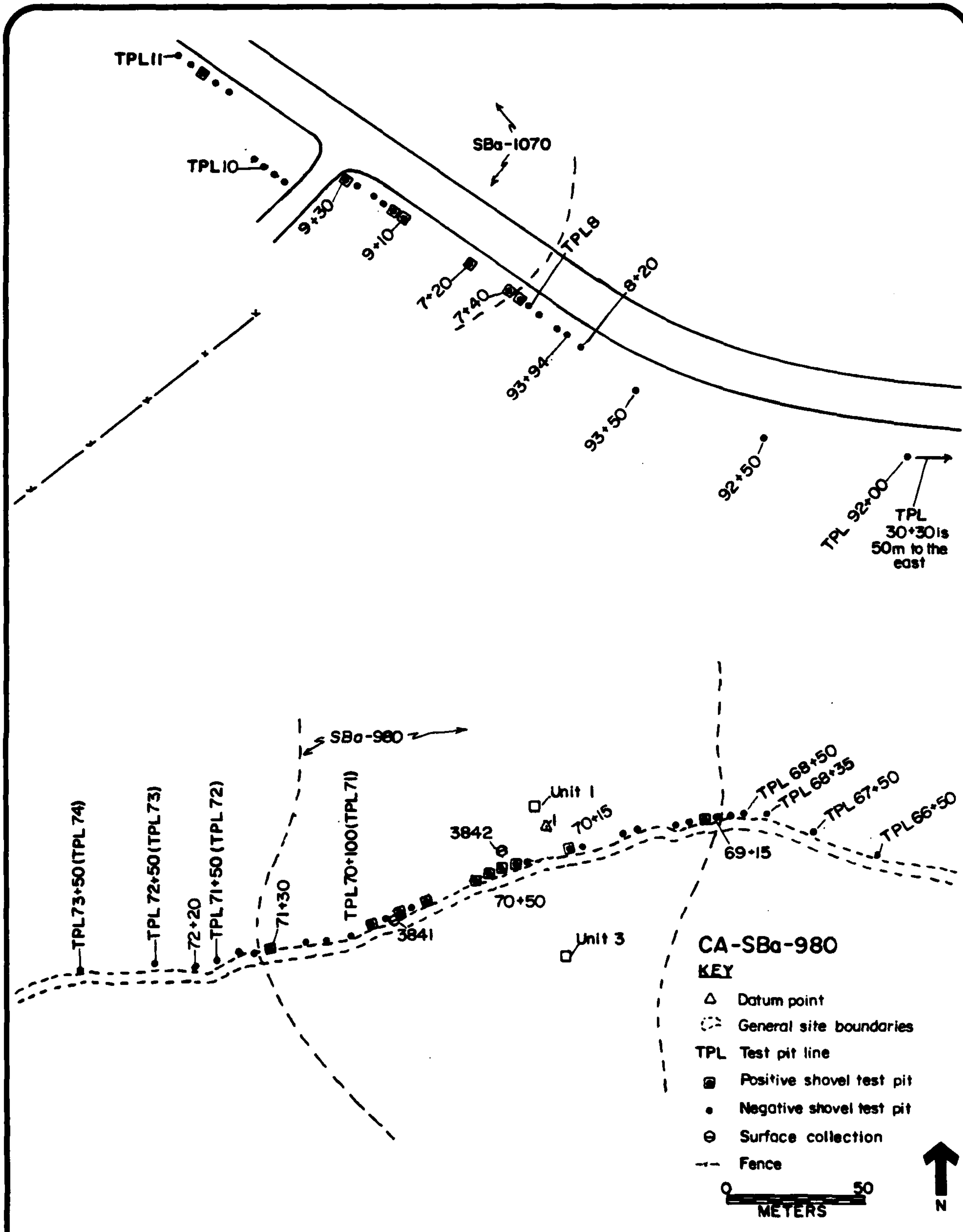

Figure 3-21. SBa-980.

Gross Site Characteristics: The site measures 500 m north-south by 150 m east-west. The depth appears to be shallow, but is at least 10 cm deep. As originally mapped by Spanne in 1971, the site did not extend far enough north to be impacted by the FO cable installation. CCP's subsurface survey revealed the presence of buried cultural materials under the surface of a road 200 m north of the recorded boundaries. Subsequent surface walkovers indicated that the newly discovered materials were contiguous with both SBa-980 to the south and SBa-1070 to the north. The impacted area was recorded as part of SBa-980, the northern boundary of which was drawn approximately 100 m north of the road. This arbitrary line is also the southern boundary of SBa-1070. The southern boundary remains where Spanne placed it, extending 150 m west from the southernmost shore of Bass Lake.

The site consists of a light density lithic and shell deposit with loci of higher concentrations of these same materials. Lithic materials include fire affected rock and a variety of chipped stone tools used primarily for killing and butchering large game, presumably deer. Nearly all species of the relatively dense shellfish remains identified from the site are rock-perching mollusks. The site does not appear to have suffered wind alteration.

Description of Investigations: Spanne discovered the site in 1971 during UCSB's survey of Vandenberg. CCP's investigations included an unproductive surface walkover early in September 1981, a subsurface survey of 19 STPs on the 15th and 16th of September (resulting in the discovery of the impacted deposits), and the excavation of two 1 m x 1 m test units in November 1981. The units were excavated to 100 cm and 80 cm STPs were placed in the bottom of each one. More than 5,200 chipped stone flakes and two tools were recovered.

SBa-998 (Figure 3-22)

SBa-998 was the first site to be investigated in response to anticipated FOCL impacts. Initial plans showed that both the FO and CL cables would pass through SBa-998; the actual installation involved the placement of the FO line on the west side of the road and the CL on the east, both within 3 m of the hard shoulder of the road.

Immediate Environmental Context: SBa-998 is a large complex deposit situated on the leading edge of the recent dunes. Soils are poorly developed or absent except in the several "windows" not covered by recent dunes.

With the exception of the introduced ice plant that borders the road, the site's vegetation is primarily chaparral. Several wetlands are present at the site, but not within 100 m of the impact corridor. Eucalyptus trees have been planted as windbreaks along its southern boundary.

Gross Site Characteristics: As recorded by Spanne in 1971, SBa-998 is a large site approximately 1,000 m x 700 m. The depth is in excess of 1 m. CCP's investigations recovered data that indicate that the site is a portion of a much larger distribution of prehistoric cultural materials extending for more than 3 km from the north bank of San Antonio Creek into the central portion

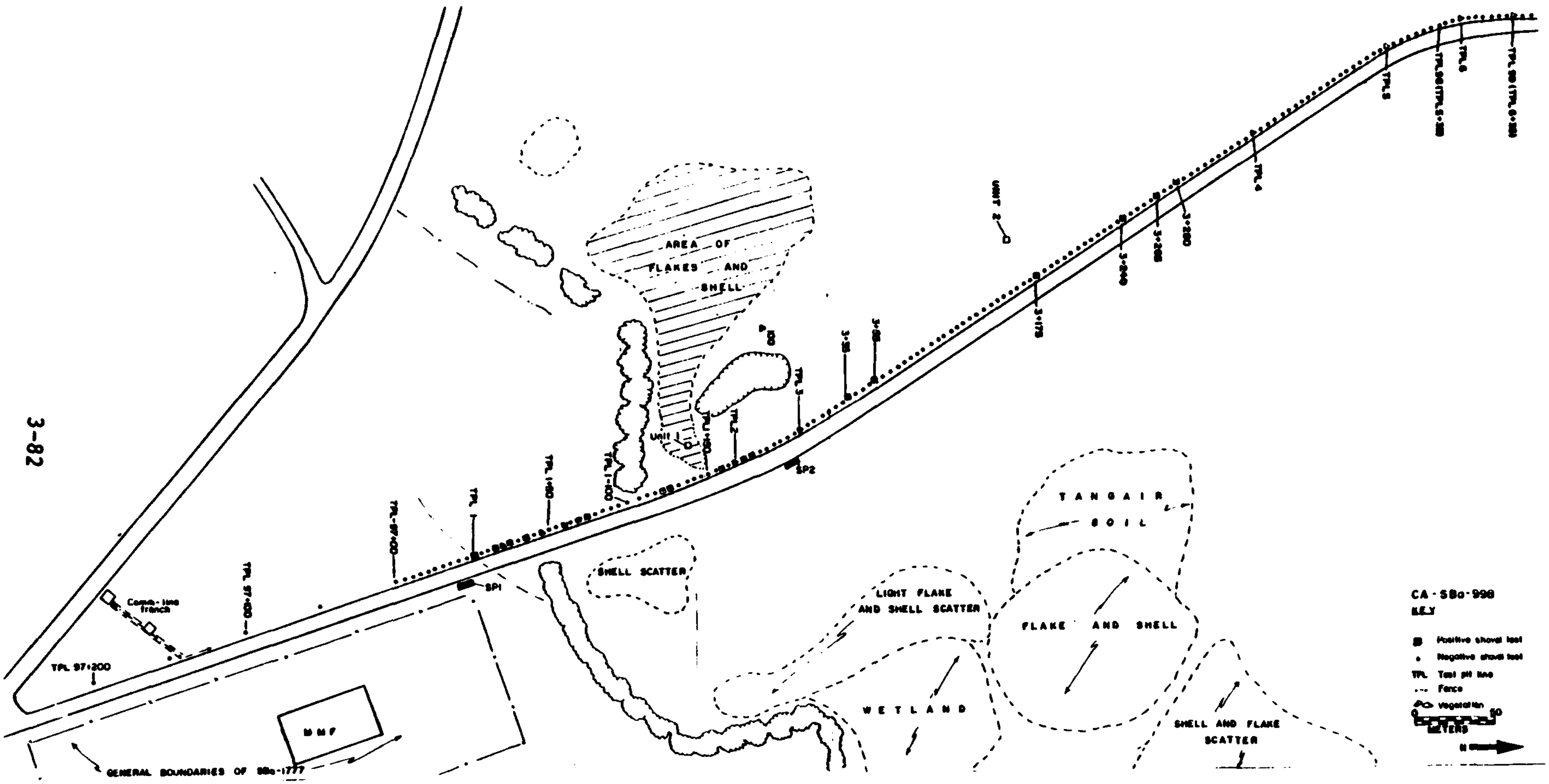

Figure 3-22. SBa-998.

of the intermediate dunes. The portion designated as SBa-998 is characterized by many loci of dense shell and lithics connected by light lithic deposits. Asphaltum globules and asphaltum coated artifacts are present at several locations.

Description of Investigations: The site was discovered by Spanne in 1972. He noted the presence of groundstone and midden and collected a slab of limonite and one point. In 1979, HDR surveyed a 3 m wide corridor on either side of the road in advance of the widening of that road. HDR returned to the site in 1980, excavating two STPs in advance of power pole installations, one to 30 cm, and one to 90 cm.

CCP surveyed a 20 m wide corridor on the west side of the road in fall 1981 supplemented by subsurface survey of 100 STPs to 50 cm at 5 m intervals. Two 1 x 1 m test units were excavated where survey data indicated the highest concentrations of cultural material, one unit 40 cm and the other 100 cm deep; STPs to 80 cm were excavated in the bottom of each unit. In addition, CCP collected two bifaces from the surface of the site.

The decision in February 1982 to install the FO line on the east side of the road resulted in further work. The additional impacts to the untested east side of the road were proceeded by surface survey and accompanied by monitoring. Seventy-eight chipped stone flakes, three tools, shell, bone, and carbon were recovered by VTN's monitors. The additional work confirmed the site boundary data gathered earlier.

SBa-1038 (Figure 3-23)

Immediate Environmental Context: SBa-1038 is located on a bluff overlooking San Antonio Creek to the south. The site's soils overlie shale bedrock and are sandy with many shale inclusions. This site is not on the recent or intermediate dunes, but on much older sands. Soil development is moderate. Vegetation consists of coastal sage scrub and grasses.

Gross Site Characteristics: Initially recorded by Spanne in 1971, the boundaries of SBa-1038 did not seem to extend far enough north to be impacted by the installation of the FO cable. Spanne noted at the time that the site had been slightly disturbed by gravel pit mining. Materials recovered during CCP's subsurface survey indicated the necessity of extending the boundaries several hundred meters north along the survey route, and the site is now believed to measure approximately 400 m x 600 m. Surface finds suggest that the site is contiguous with SBa-1037 and -1565 to the east.

Description of Investigations: The site was discovered by Spanne during UCSB's 1971 survey of Vandenberg Air Force Base. CCP's investigations included surface and subsurface surveys in September 1981 and unit testing in November of the same year. Thirty-five STPs were excavated within the boundaries of the site to a depth of 50 cm. Three 1 x 1 m test units were excavated to depths of 60 cm, 100 cm and 120 cm at locations where survey data indicated the highest densities of cultural materials. Findings include 130 chipped stone flakes, one biface, shell, bone and carbon.

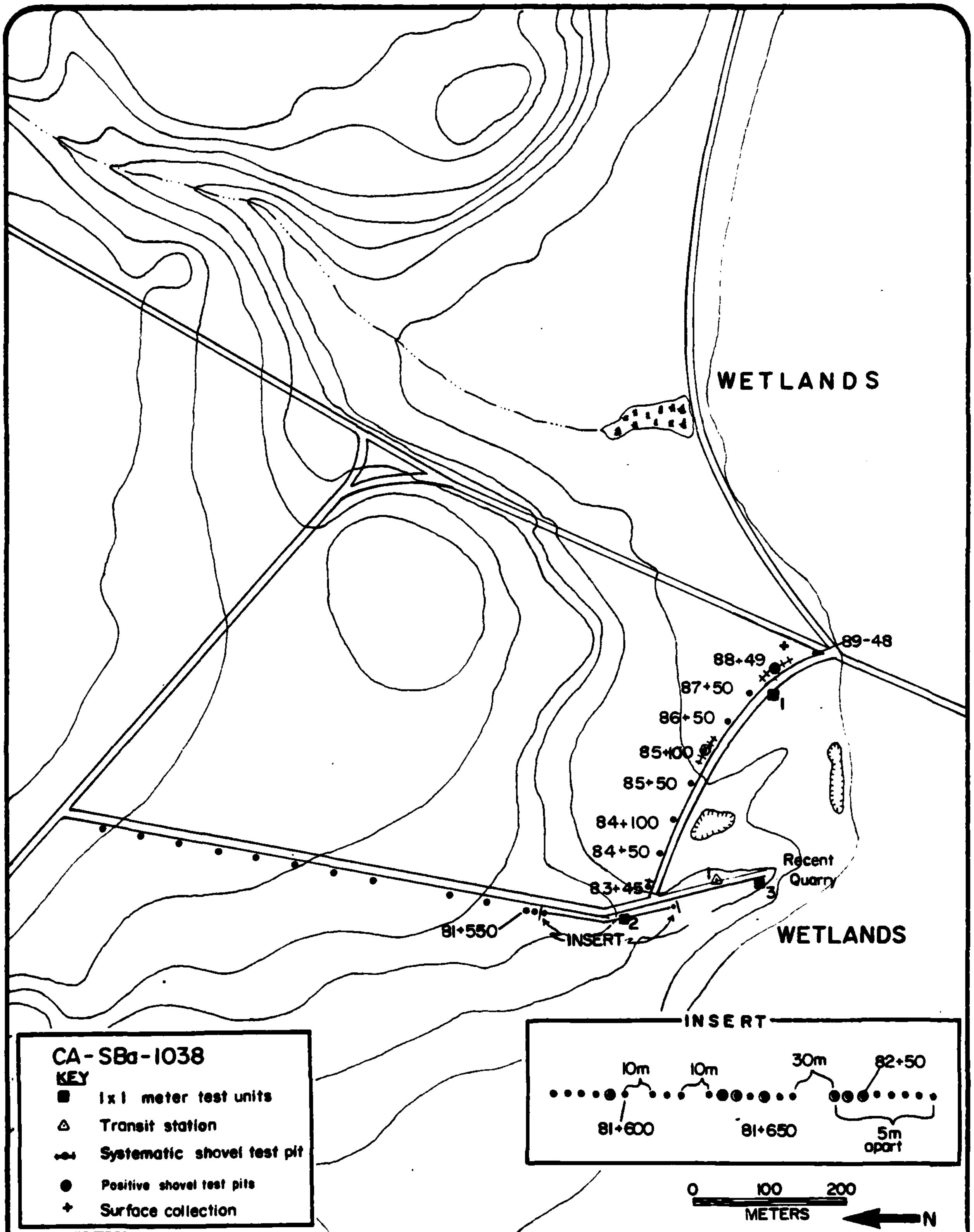

Figure 3-23. SBa-1038.

SBa-1070 (Figure 3-24)

The FO cable route passed through SBa-1070 in a road-cut that is, at places, several meters below the original surface. The site extends for 150 m; depth is undetermined. CCP's examination of the surface in the surrounding dunes suggests that SBa-1070 is not a discrete site but rather a portion of a large continuous deposit extending from and including the sites on the bluffs overlooking San Antonio Creek (SBa-984, -983, -982, -981) through SBa-980, -1070, -1071, and -706 to SBa-998.

Immediate Environmental Context: SBa-1070 is located on the leading edge of the intermediate dunes overlooking one of two drainages feeding Bass Lake. Site matrix is loose sand displaying no soil development. Vegetation is predominantly coastal dune chaparral with eucalyptus and wetland species along the south and east periphery of the site.

Gross Site Characteristics: Spanne recorded the site as approximately 300 m x 100 m; more recent surveys indicate that the site extends another 200 m south to SBa-980 and 100 m east to SBa-1070E. The site, described by Spanne as a seasonal village, consists of light lithic and shell scatters. Subsequent investigations tend to support that description. Slight aeolian erosion was noted in 1973 and 1979.

Description of Investigations: Spanne first recorded the site in 1973 as a result of UCSB's survey of the base. HDR resurveyed the site in 1979 and 1980 and described the presence of dunetop middens. Neither Spanne nor HDR did any subsurface testing at the site.

CCP surveyed the impact corridor for the placement of the CL in April 1981. This survey involved surface walkover of a 20 m wide corridor and the excavation of three STPs to 50 cm. In the fall of 1981, CCP excavated 26 STPs to 50 cm in order to define the boundaries of the site. CCP also excavated one 1 m x 1 m controlled test unit to 120 cm with a single STP to 80 cm in the bottom of that unit. This was placed south of the road on the ridge where surface artifacts of diagnostic value were collected. More than 1,200 chipped stone flakes, four bifaces, one scraper and one undetermined tool, fire-affected rock, shell, bone and carbon were recovered. The locations of the collected artifacts, STPs and the controlled excavation unit were determined with transit and stadia by triangulation to permanent prominent landmarks.

SBa-1172 (Figure 3-25)

The FO cable route passed through the apparent center of SBa-1172 in a bulldozed road or firebreak.

Immediate Environmental Context: SBa-1172 is recorded as being located midway between SBa-704 and a road on the steep descent from Burton Mesa to the San Antonio Creek floodplain. A firebreak passes through the site. The surface of the site is eroded shale bedrock showing little soil development. Vegetation is coastal sage scrub.

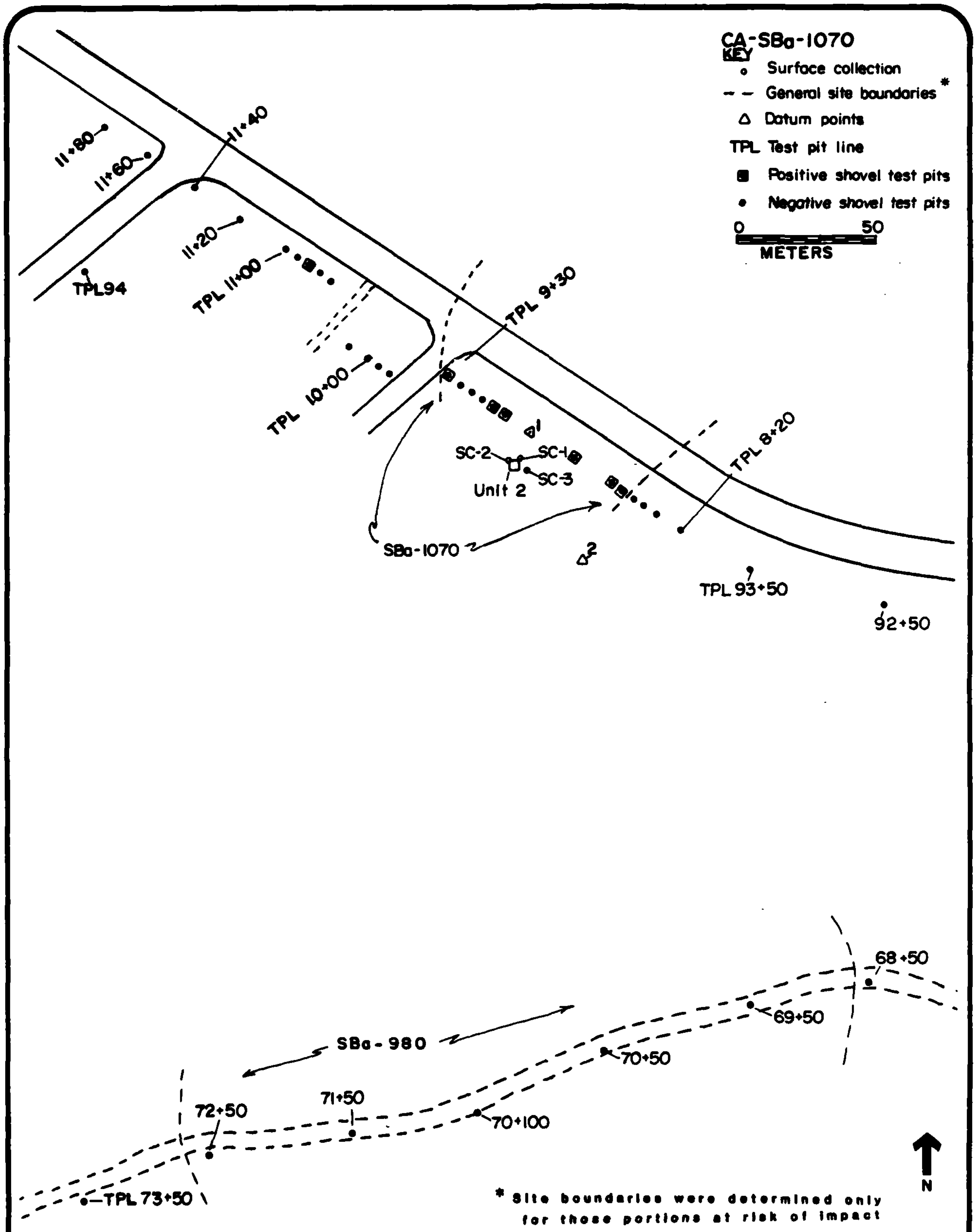

Figure 3-24. SBa-1070.

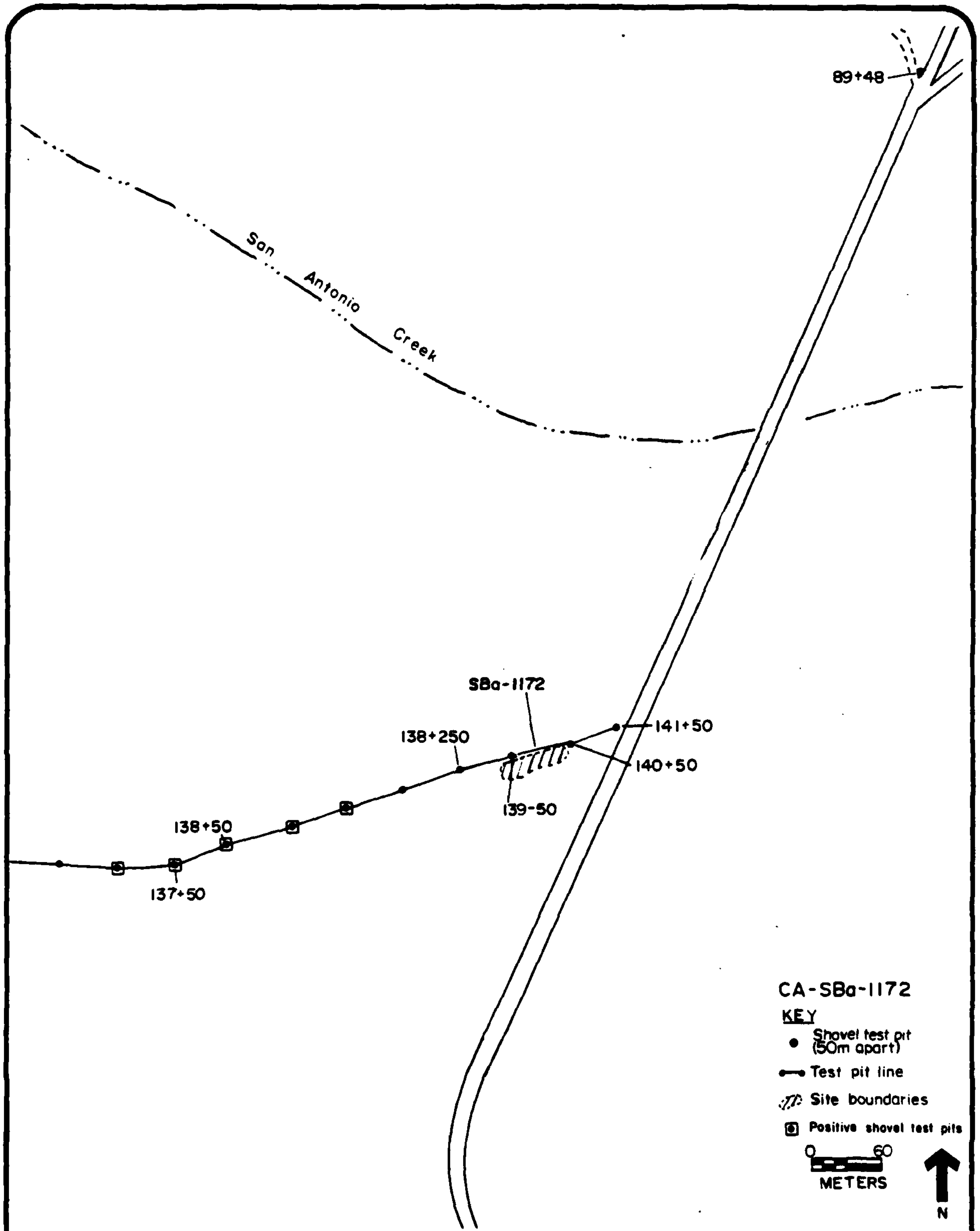

Figure 3-25. SBa-1172.

Gross Site Characteristics: The site was described by HDR as a high density flake scatter and a possible quarry containing debitage, possible hammerstones and possible cores. According to HDR's map, the site extends down slope for approximately 100 m and 30 m on either side of the firebreak. The vertical dimensions are unknown. CCP's crews found no trace of the site during surface or subsurface survey. It is possible that SBa-1172 and SBa-704 are the same site.

Description of Investigations: HDR's survey involved the examination of a 30 m wide corridor using zigzag transects. CCP examined a 20 m wide corridor centered on the firebreak at 5 m transect intervals. In addition, two STPs were excavated within the recorded boundaries of the site. No cultural materials were collected.

SBa-1730 (Figure 3-26)

SBa-1730 is located on the south side of two roads. Materials were discovered during subsurface survey in the road-cuts of each of these roads and on the top of the dune, which was cut to make way for the roads. The installation of the FOCL cables was in the shoulder of the roads with approximately 300 m of the trench being within the site boundaries.

Immediate Environmental Context: The site's matrix is loose sand of intermediate age. Vegetation consists of sparse coastal sage scrub and, after revegetation connected with MX development, introduced grasses.

Gross Site Characteristics: The known portions of the site extend for several hundred meters along the south sides of two roads. Although there are gaps in the surface and subsurface indicators of more than 50 m, the likelihood of buried materials prompted the assignment of a single site number to the area.

Description of Investigations: CCP conducted surface and subsurface survey of the 20 m wide impact corridor in August 1981. Surface survey was accomplished at 5 m transect intervals. Sixty-three 50 cm deep STPs were excavated along a line 10 m from the roads' south edges (in the center of the survey corridor). A single 1 m x 1 m test unit was excavated in 20 cm levels to a depth of 40 cm, with an STP to 80 cm in the bottom of the unit. The test unit was placed atop the dune south of the intersection where surface indicators were frequent. A total of 57 chipped stone flakes were recovered from the site.

VTN monitored road grading in the general area of SBa-1730 in October 1980. One isolated chipped stone flake was observed in the vicinity.

Stage Processing Facility - B

The Stage Processing Facility - B (SPF-B) and its associated access road are situated in the western portion of the San Antonio Terrace. The dunes in this area are generally flatter with less topographical relief than is found in the dunelands of the northern and eastern portions of the San Antonio Terrace. The facility occupies approximately 4,200 m² of duneland.

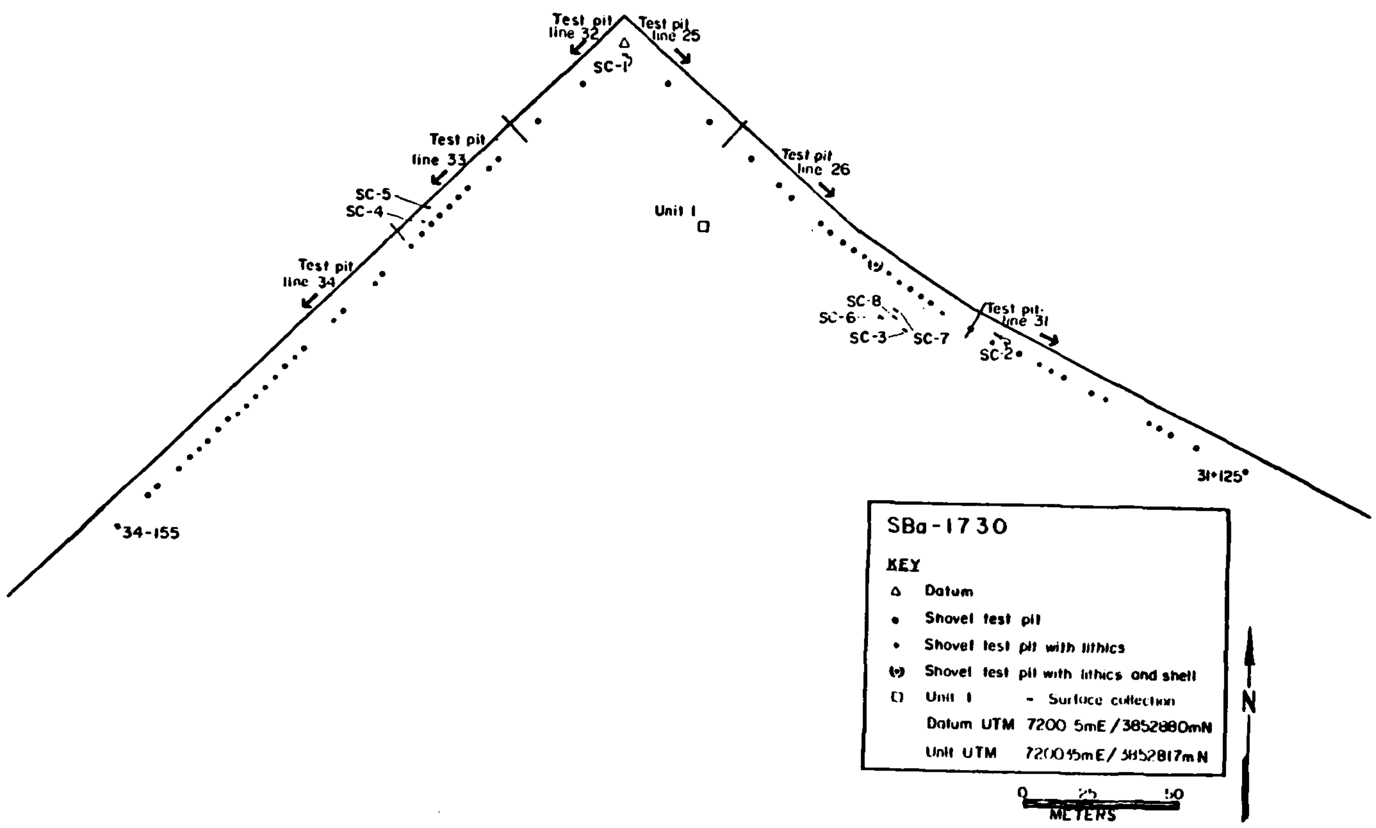

Figure 3-26. SBa-1730.

HDR conducted a preliminary survey of the proposed facility and access road locations in 1979. Prior to HDR's field reconnaissance, vegetation had been removed from a portion of the access road and from the facility location with heavy equipment. A 60 m wide corridor along the access road alignment was surveyed in 10 m transect intervals. The proposed facility location was surface inspected in 5 m transect intervals.

The construction of the MX Missile stage processing facility required that archaeological investigations be made of the proposed site of construction. The grading plans indicated impacts to maximum depths of approximately 2 m in the 40,000 m^2 zone of impact. One site (SBa-1193) was revealed in the access road cut.

SBa-1193 (Figure 3-27 and 3-28)

Immediate Environmental Context: The SPF-B is located 1 km northeast of the north edge of the San Antonio Creek floodplain, 800 m from the Southern Pacific Railroad. Soils are primarily loose dune sand with areas of somewhat more consolidated and slightly darker sand in the southeast portion of the zone of impact; there is little evidence of soil formation.

Gross Site Characteristics: Testing within the construction zone did not result in the discovery of the horizontal limits of the deposit in any direction, i.e., the deposit is larger than the construction zone. The limits of construction were 120 m x 200 m. The tested portions of the deposit range in depth from less than 1 m to more than 2.6 m.

Secondary deposits of windblown flakes occur throughout the SPF-B zone of impact. Surface indicators were very limited and included occasional, very small flakes, a fire-affected cobble fragment and a large Monterey chert flake. The last two were the only artifacts seen in the impact zone which did not appear to have been secondarily deposited. Subsurface investigations yielded high densities of chipped stone flakes, demonstrating the need for additional investigation.

Description of Investigations: HDR conducted surface survey and surface collection and began the excavation of two 2 m^2 test units in October 1980. One of HDR's test units was placed where surface finds were greatest, i.e., south and slightly west of the terminus of a road alignment. The other unit was located north of the terminus of the access road in an area of much lower density surface indicators. Each of these units was excavated to a depth of 120 cm and yielded very high densities of windblown flakes in the 40 cm to 80 cm levels. Loose sand matrix forced the closure of the units.

CCP's investigations at the site included transect surface survey of the impact zone at 3 m intervals, excavation of 374 two level STPs (to 40 cm and 80 cm) and excavation of 29 1 x 1 m test units. One hundred eighty-seven of the STPs were excavated in linear arrays focused on the site's apparent center and on locations of surface finds; the additional 187 STPs were excavated as a stratified random sample. Subsurface flakes were found throughout the impact zone, and there was the lack of correlation between surface indicators and subsurface materials.

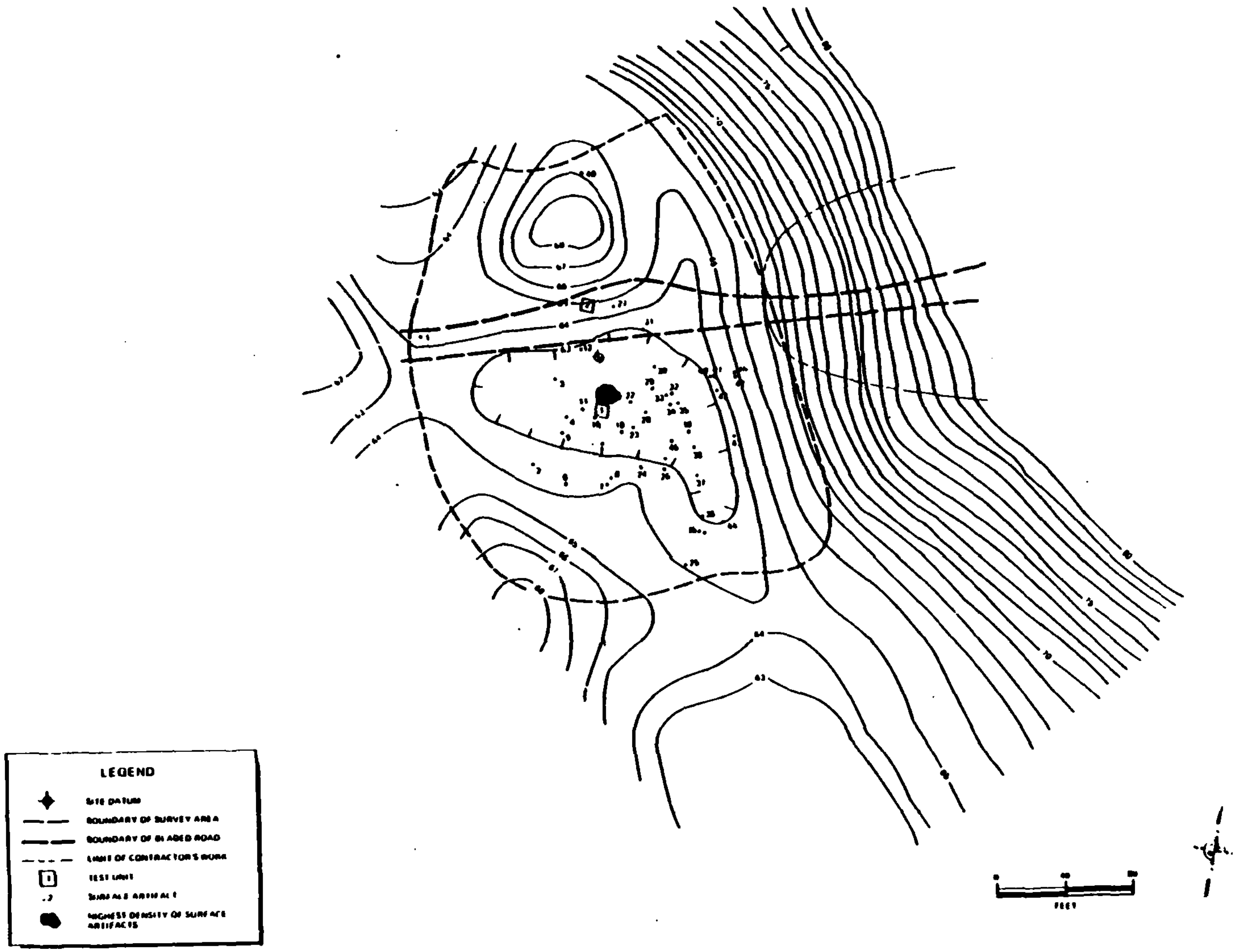

Figure 3-27. Results of Premitigation Testing at SBa-1193 (HDR Map).

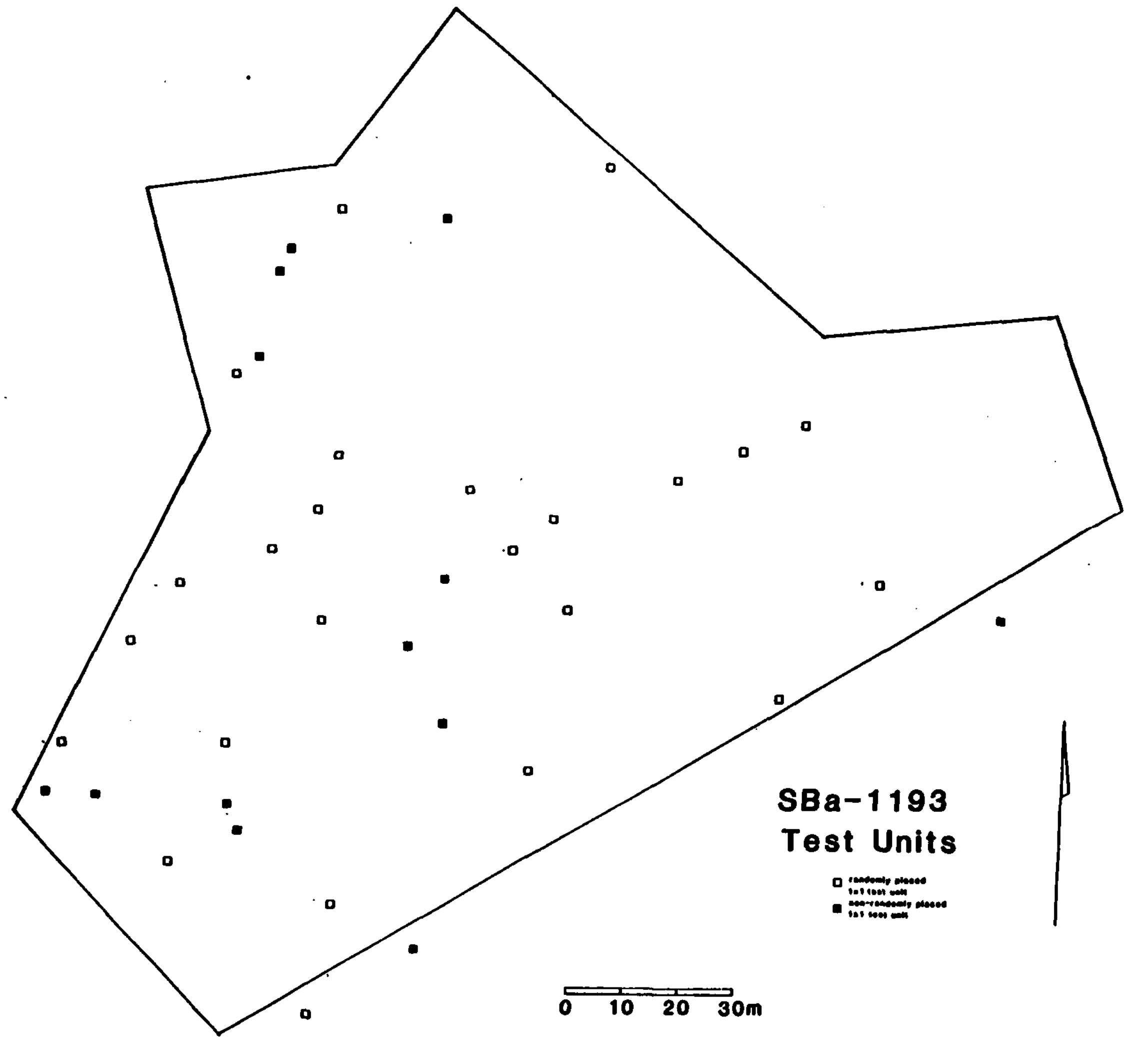

Figure 3-28. Test Units Excavated by CCP at SBa-1193.

In February 1981 the principal investigator, co-principal investigator, laboratory director and the field director jointly decided to extract a nonrandom 40 m^3 sample based on apparent clustering of the STP data. Ten cubic meters were to be extracted from each of four apparent clusters. The locations of these clusters were at the extreme eastern end of the impact zone where HDR crews had initially discovered the site, at the extreme southern corner of the impact zone, in the approximate center of the impact zone, and in the northern portion of the impact zone near a small wetland.

The judgemental placement of units was abandoned after the excavation of 14 judgementally placed test units, and another 18 units were placed randomly without stratification in order to acquire a more representative sample of the site. Depths of the units ranged from 30 cm to 250 cm, and a total of 43.1 m^3 was excavated.

Four more nonrandom units were excavated in March 1981 after VTN monitors observed that impacts to the site were exceeding the limits defined in the grading plans. A 20 cm to 30 cm stratum of darkened soil containing high chipped stone flake densities was encountered at about 210 cm. The comparitively large size of the flakes and the visable wind polish suggest the possibility of a wind deflated deposit.

Weather Station Survey (Figure 3-29)

Immediate Environmental Context: The weather station is located southeast of the intersection of two roads on a dune ridge. The soils dune sands semistabilized by coastal dune scrub.

Gross Site Characteristics: No site was discovered at this location.

Description of Investigations: CCP surveyed the surface of the proposed weather station site in transects at 5 m intervals. Twenty STPs were excavated to a depth of 50 cm at 10 m intervals as a check for subsurface deposits; no cultural material was recovered.

Eastern Shelter Area (Figure 3-30)

The eastern shelter project area is located within the central portion of the San Antonio Terrace, a topographically dynamic area characterized by coalescing parabolic dunes semi-stabilized by coastal dune chapparal and occasional wetland plant communities.

Specific siting plans for the eastern shelter launch facilities (TS-1 and TS-2) have been abandoned. The facilities were to be located east of a road and north of the MAB, and the project would have required the construction of access roads extending north and northeast from the MAB to the facilities.

The cultural resources of the eastern shelter area have been investigated by five organizations: HDR, UCSB-OPA, COE, CCP, and WESTEC Services, Inc. The area was first examined by HDR archaeologists in October 1979 and May and June of 1980. HDR surveys were conducted at 15 m intervals along the proposed road alignments and in the proposed TS locations. Three

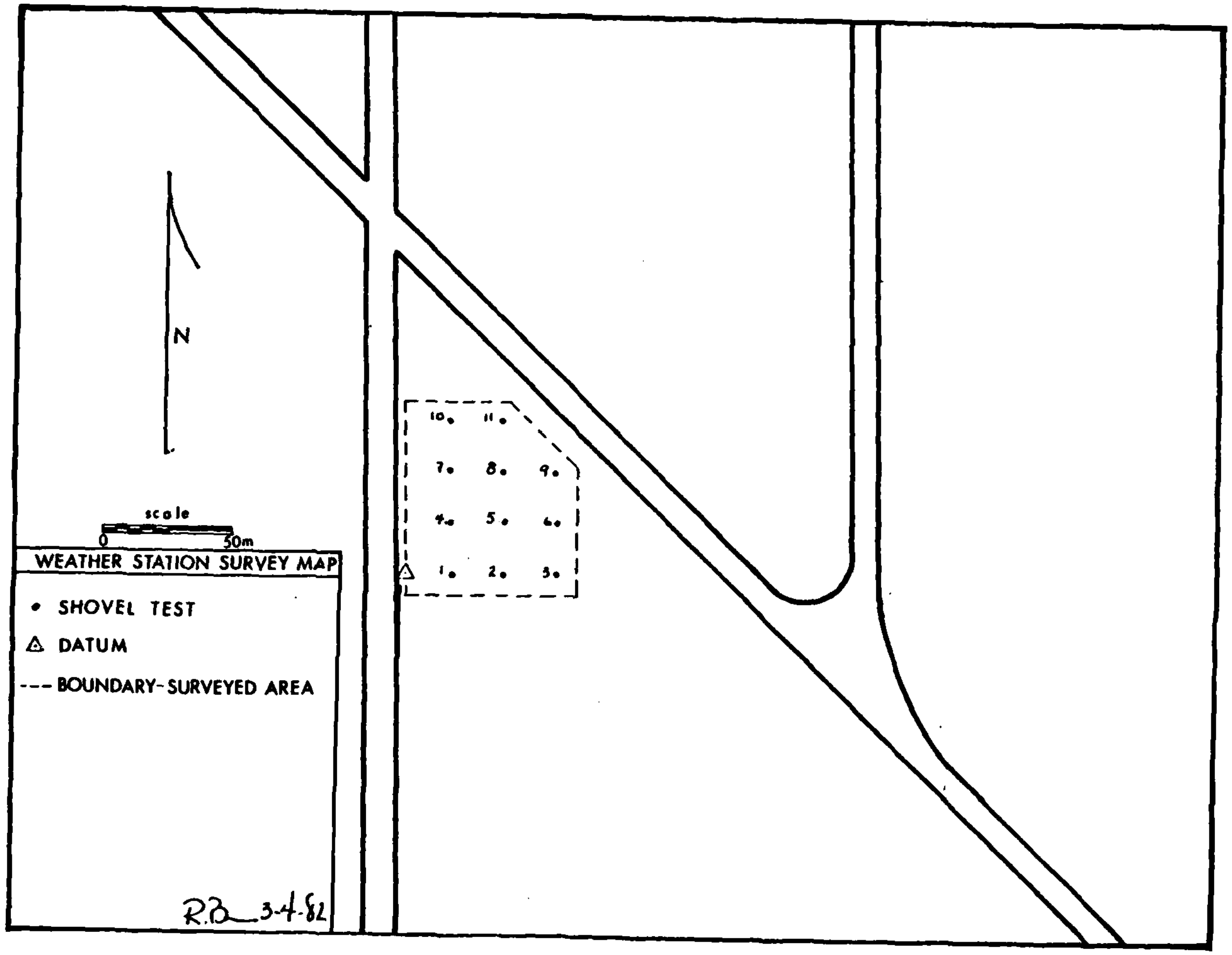

Figure 3-29. Weather Station Survey.

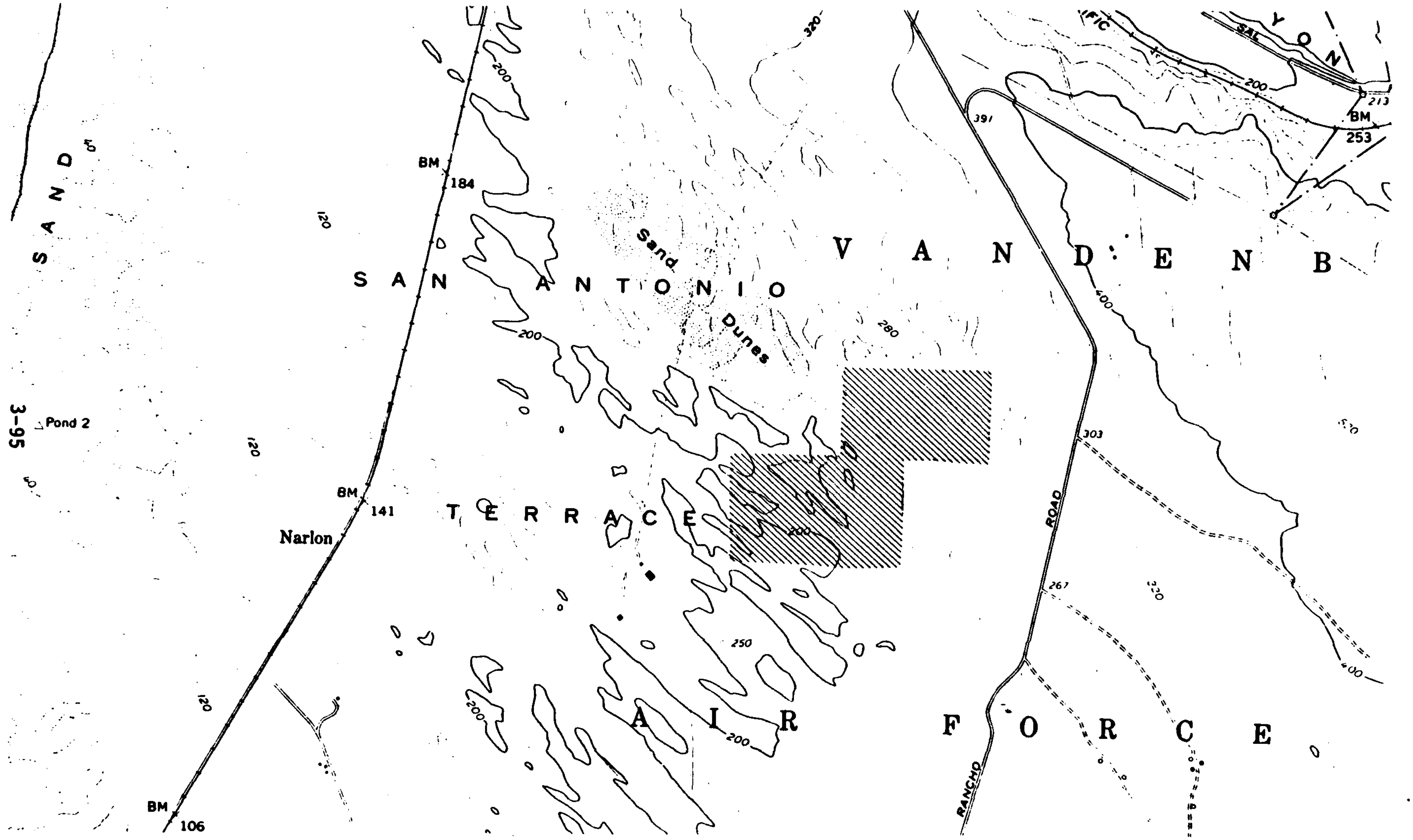

Figure 3-30. Eastern Shelter Block Survey Area.

previously unrecorded sites (SBa-540, -577 and -581) and a resource area were discovered and recorded by HDR personnel. HDR collected materials from the surface of several of the newly discovered sites and from intersite locations.

UCSB-OPA's work in the Eastern Shelter area was limited to surface survey and the excavation of 13 STPs at SBa-581.

CCP archaeologists resurveyed old road alignments within the eastern shelter area in March 1981. These initial surveys by CCP were requested by the COE to verify the presence of sites in the corridors to determine whether redesign was necessary. Once the presence of the sites was confirmed, a new route north of the original alignments was proposed by the COE and AFRCE and subsequently surveyed by CCP. Three new sites (SBA-1682, -1683 and -1684) were discovered as a result of this second survey.

Because site densities were expected to be high in the Eastern Shelter area, the COE specified in the Scope of Work that blocks of land be surveyed prior to the design of the roads and shelters. (Providing advance site location data avoids the expense and delay of redesign and mitigation.) Block survey was begun in April 1981.

Two survey blocks (A and B) large enough to accommodate considerable repositioning of the road alignments if resource avoidance was necessary were delimited. Block A measured 500 m north-south by 750 m east-west (375,000 m^2), and block B measured 300 m north-south by 700 m east-west (210,000 m^2). Block A was situated southwest of block B, and its western boundary was adjacent to the recently constructed road to the planned TS-2. The surface of both blocks was surveyed by crew members walking parallel transects at 5 m intervals. Subsurface survey involved the placement of STPs at 50 m intervals and subsequent tests for isolation where cultural materials were encountered.

In addition to the survey level STPs, lines of STPs were excavated through sites along transects placed through sites located within the most recently designed road alignment. Site boundaries were well defined by this method. Data from the STP transects also revealed the presence of two secondary deposits of well-sorted lithic flakes, one in SBa-581 and one in SBa-1682. This information was very useful in the planning stages of the study of post-depositional processes (see Chapter 5).

SBa-540 (Figure 3-31)

Immediate Environmental Context: SBa-540 is situated on several adjacent dune tops in the southern portion of the eastern shelter area. The site lies within 200 m of three major wetlands.

Gross Site Characteristics: As mapped by HDR, the site measures approximately 150 x 150 m; its depth is unknown. It is a light lithic and shell scatter with loci of relatively more concentrated materials. Lithic materials seen on the surface included debitage and fire affected rock. Shell species include *Haliotis* sp., *Mytilus californianus* and *Chryptochiton stelleri*. The site is undisturbed.

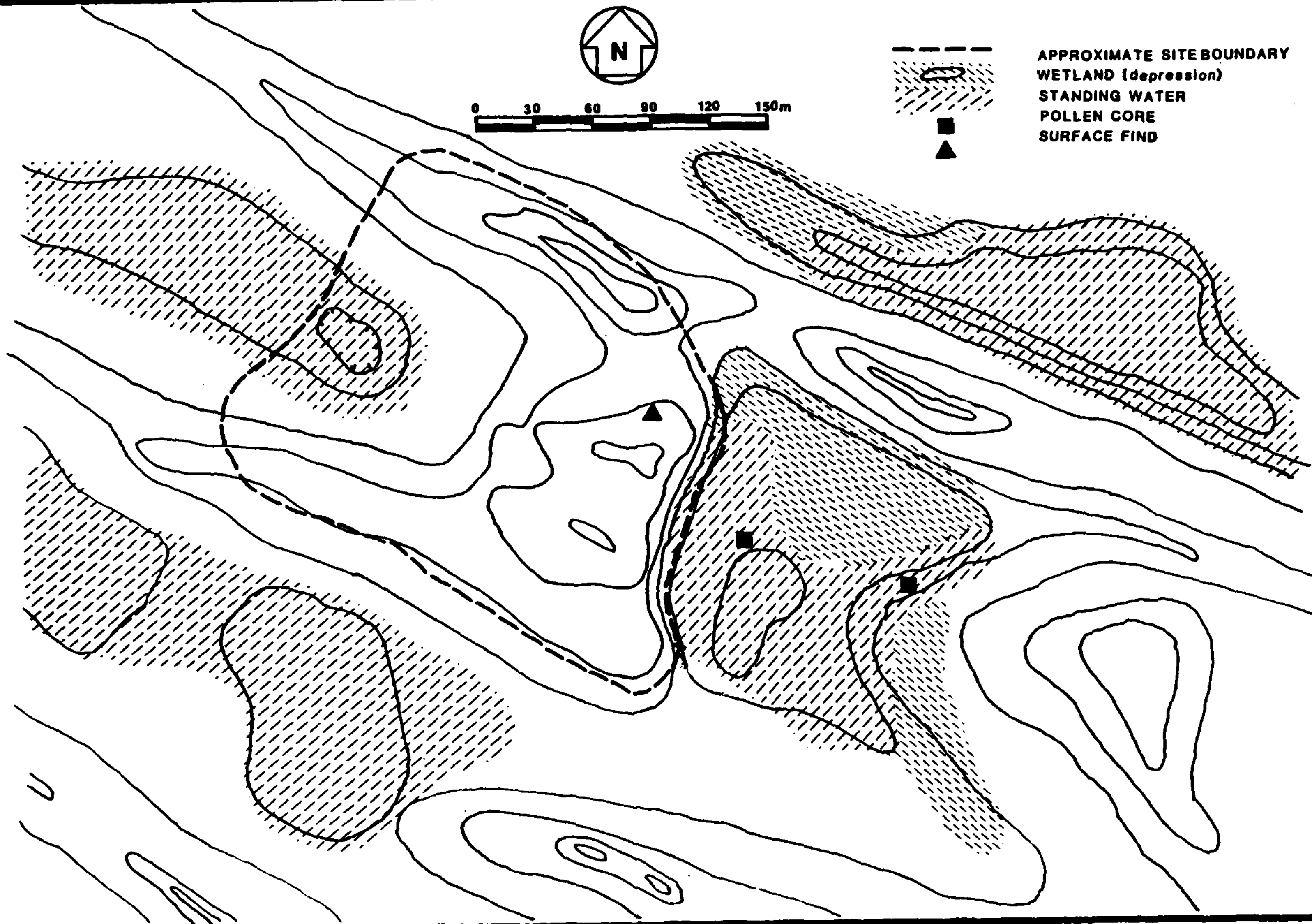

Figure 3-31. SBa-540.

Description of Investigations: HDR discovered and recorded the site during initial surveys of the eastern shelter road alignments in October 1979. Because the site was not to be impacted, it has not been systematically investigated since that time, although CCP crews visited the site on several occasions. Pollen cores were extracted from the adjacent wetland (Turtle Pond) and the site record was updated. Pollen coring and analysis of 1928 Fairchild aerial photos suggest that Turtle Pond is quite young and/or only very occasionally filled with water. The organic mat developed in the bottom of the pond is less than 2 cm thick, and the 1928 aerials indicate no water in the pond.

SBa-577

SBa-577 is recorded by HDR as a light lithic scatter in a swale adjacent to a wetland 200 m west of SBa-540. CCP crews were unable to relocate the site.

SBa-581 (Figure 3-32)

Immediate Environmental Context: SBa-581 is located between 450 m and 1000 m east of the TS-2 road and 1000 m north of the MAB in a 900 m long swale. The older soils exposed in the swale "window" (see Chapter 4) contain chipped stone artifacts. A remnant mound of intermediate dune sand, connected to the northwest ridge, is situated midway down the swale. Perennial wetlands can be found at either end of the swale, and Turtle Pond is 100 m south across the southwest ridge. The remaining site vegetation is coastal sage scrub (dune phase) with noticeably higher densities occurring on the older soils exposed in the swale.

Gross Site Characteristics: The site measures 650 m by 100 m, with the long axis aligned parallel to the prevailing northwest winds. The northwest 200 m of deposit and the southeast 150 m consist of a surface scatter of relatively large chipped stone flakes resting on old dune soils. These materials may be in situ or they may be lag, deposited on sands which once overlaid the area and which have since been deflated.

Surface indicators are not apparent on the mound of sand in the center of the site. However, STP excavations revealed the presence of windblown flakes in the mound. The source of the windblown flakes is not known, but it could be from as far away as the beach (4.3 km upwind) or as near as the immediately adjacent northwest end of SBa-581.

Description of Investigations: The site was discovered in May 1980 by HDR crews surveying the eastern shelter road alignments. UCSB-OPA's subsequent examination of the site in the same year involved surface transects at 2 m intervals, the excavation of 13 STPs and the recording of the locations of surface finds with a transit and stadia rod. The STPs ranged in depth from 100 cm to 120 cm. Surface materials were not collected.

CCP's investigations involved systematic surface survey of the northern 1/3 of the site, unsystematic walkover of the remainder of the site, and the excavation of 87 STPs to a depth of 50 cm at 5 m intervals along a single

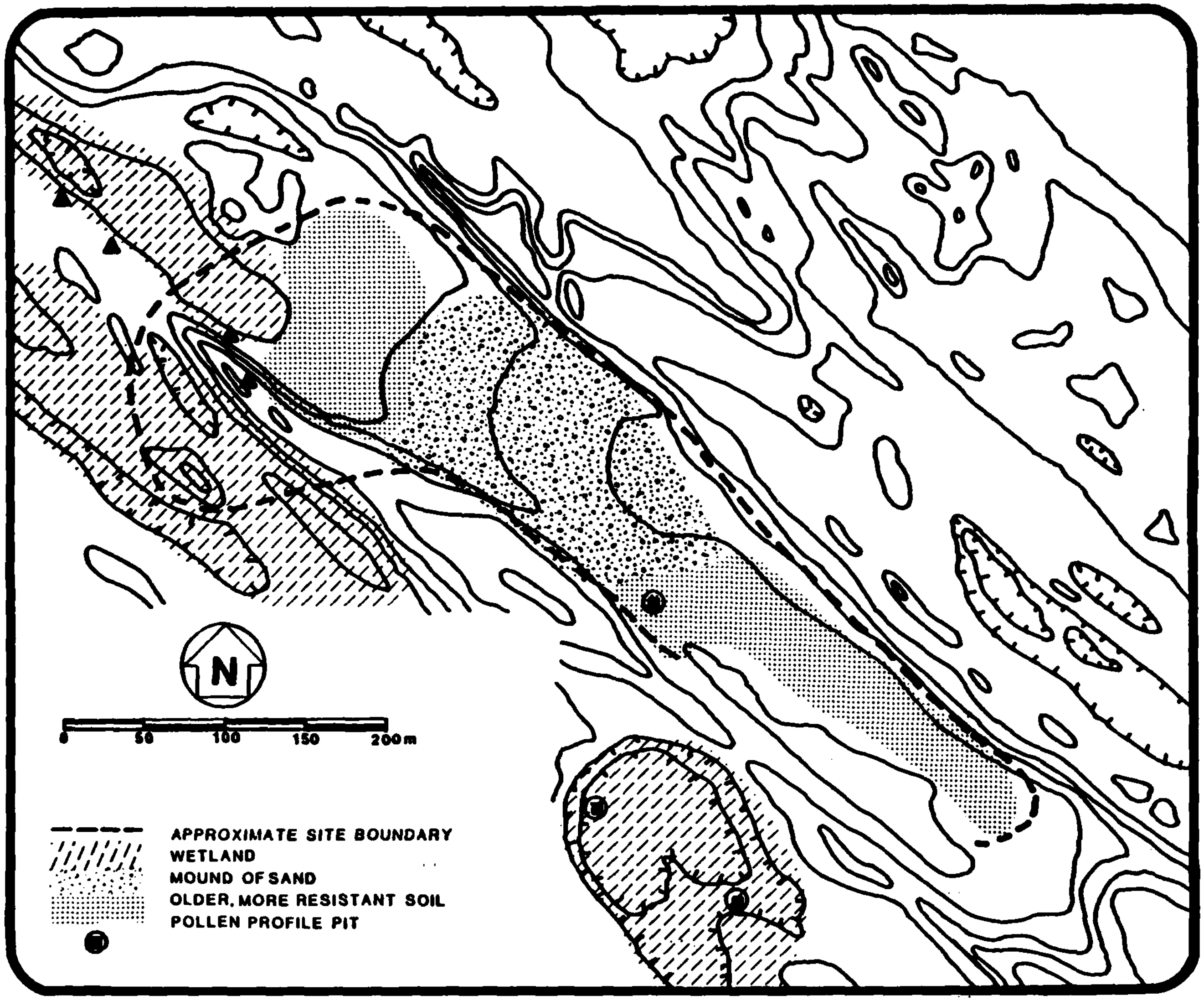

Figure 3-32. SBa-581.

transect parallel to the long axis of the site. The STPs were excavated to establish the site's boundaries and to gather preliminary information on artifact displacement by wind. A controlled surface collection was conducted over a portion of the site. A total of 36 chipped stone flakes and one projectile point were recovered.

Pollen samples were obtained from the south central portion of the site.

SBa-1682 (Figure 3-33)

Immediate Environmental Context: The site is located entirely on dune sands of intermediate age in a swale and adjacent to a low ridge 200 m north of the northwest end of SBa-581. Vegetation is coastal sage scrub (dune phase) with wetland species at the east end of the swale.

Gross Site Characteristics: The site measures 100 m by 150 m with the long axis parallel to the prevailing northwesterly winds. The portion of the deposit in the swale consists of a sparse scatter of relatively large lithic material (too large to be transported by the wind). The possibility exists that these materials are not in situ, but have reached their present positions in the bottom of a swale as a result of the deflation of previously underlying sands. The materials found on the ridge to the southwest were all subsurface windblown flakes.

Description of Investigations: SBa-1682 was discovered during CCP's survey of the road to TS-2 in April 1981. Eighty-three STPs were excavated to 50 cm at 5 m intervals on five transects in June of the same year in an attempt to define the site boundaries and to provide preliminary data on aeolian artifact displacement. Thirty-one chipped stone flakes were recovered, and fire-affected rock and burned bone were observed.

SBa-1683 (Figure 3-34)

Immediate Environmental Context:: The site is located in a swale 150 m northeast of SBa-1682. Soils are loose dune sands. Vegetation at the site consists of coastal sage scrub (dune phase) for the majority of the site with wetland species in the low parts of the swale where the ground surface intersects the water table.

Gross Site Characteristics: SBa-1683 measures an estimated 20 m north-south by 25 m east-west. Its depth is unknown. The site is a scatter of relatively large lithic flakes and fire-affected cobbles. The fire-affected cobbles are in close enough proximity to one another to suggest the presence of a hearth, but there is no trace of charcoal or soil discoloration, suggesting that these materials may have been lowered to their present elevations by the deflation of underlying sands.

Nature of Investigations: The site was discovered during CCP's April 1981 survey of the route of the proposed road leading to the proposed site for TS-2. In June 1981, 49 STPs were excavated to 50 cm at 5 m intervals on three transects placed through the site. These STPs were designed to define the site boundaries and to provide preliminary data on artifact displacement by wind. Five flakes were recovered, and fire-affected rock, shell and bone were observed.

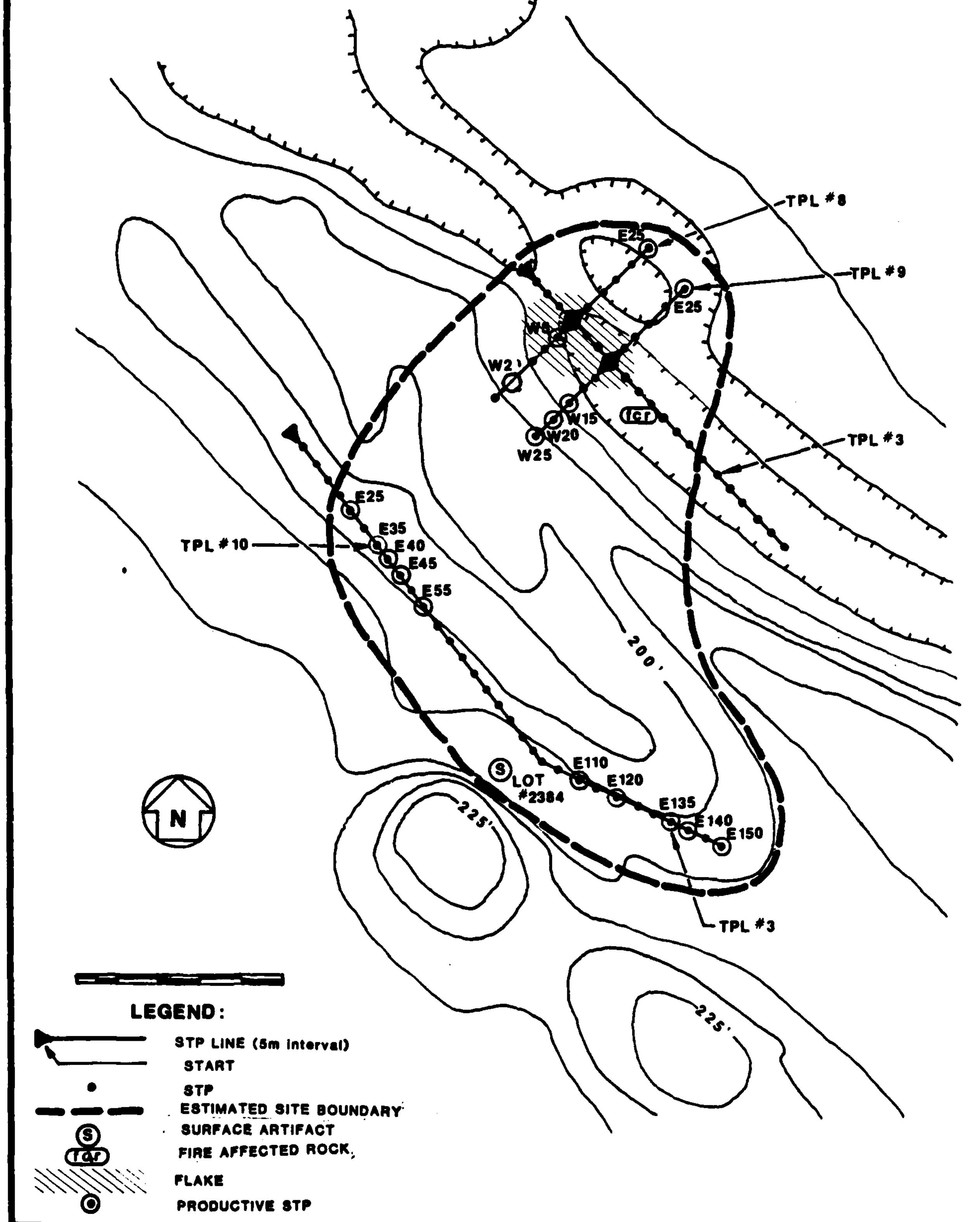

Figure 3-33. SBa-1682.

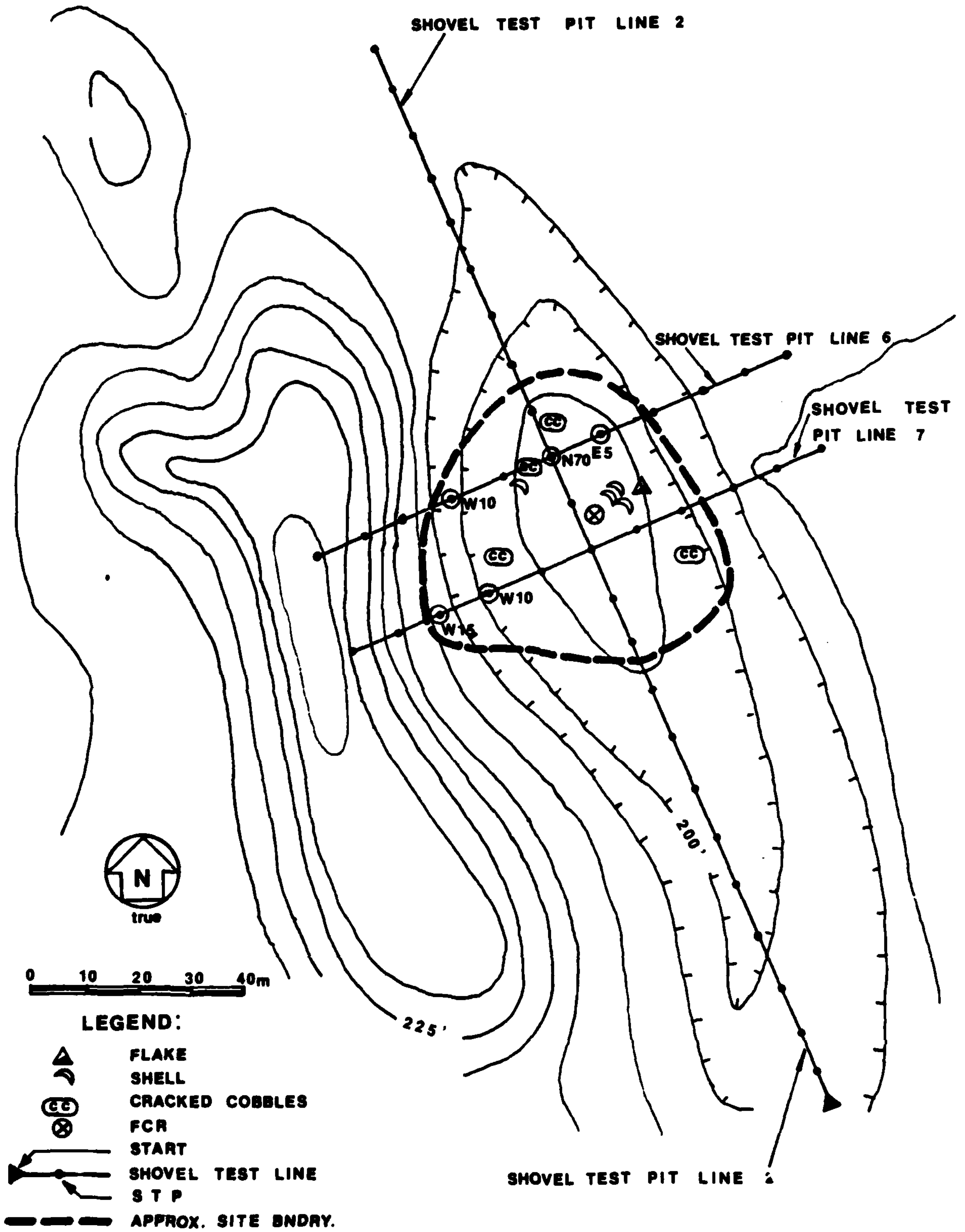

Figure 3-34. SBa-1683.

SBa-1684 (Figure 3-35)

Immediate Environmental Context: SBa-1684 is situated on top of an isolated dune peak 200 m northwest of the northwest end of SBa-581. Soils are loose dune sands semistabilized by coastal dune scrub vegetation. A large wetland is present in the swale 50 m southwest of the site.

Gross Site Characteristics: The site is estimated to measure 70 m north-south and 115 m east-west. Its depth is unknown. There appear to be two components present, a primary surface deposit of large utilized and nonutilized flakes, and a secondary surface and subsurface deposit of small windblown flakes.

Description of the Investigations: The site was discovered in April 1981 during CCP's survey of the proposed TS-2 road alignment. One hundred three STPs were excavated to 50 cm to determine its horizontal extent and to gather preliminary data on the displacement of artifacts by wind (see Chapter 5). Seven chipped stone flakes were recovered.

SBa-1724 (Figure 3-36a)

Immediate Environmental Context: SBa-1724 lies in an elevated swale 100 m northeast of the southeast end of SBa-581. Soils are loose sands and vegetation is coastal dune phase sage scrub. The nearest wetland is 250 m to the southwest.

Gross Site Characteristics: SBa-1724, a relatively small site, measures approximately 30 m southwest-northeast and 50 m northwest-southeast. Its depth is unknown.

Description of Investigations: The site was discovered in April 1982 during CCP's resurvey of the proposed road alignment to TS-2. Seven gray chert flakes were seen on the surface. CCP relocated and mapped the site in the fall of 1981. No subsurface archaeological work was done.

SBa-1725 (Figure 3-36b)

Immediate Environmental Context: The site is situated on a dune ridge within the intermediate dunes 100 m northwest of the recorded location of SBa-577. Soils are loose dune sand semistabilized by sparce coastal sage scrub (dune phase). Two wetlands are within 50 m of the site, one to the northeast and another to the southwest.

Gross Site Characteristics: As currently known, the site consists of a sparce scatter of chert flakes extending over a surface area of approximately 50 m east-west x 65 m north-south. Its vertical dimensions are unknown.

Description of Investigations: The site was seen by HDR crews during their survey of the eastern shelter road alignments. Although HDR did not record the site, they mapped the location of several artifacts at the site's location. The site was subsequently recorded by CCP. No subsurface work was done.

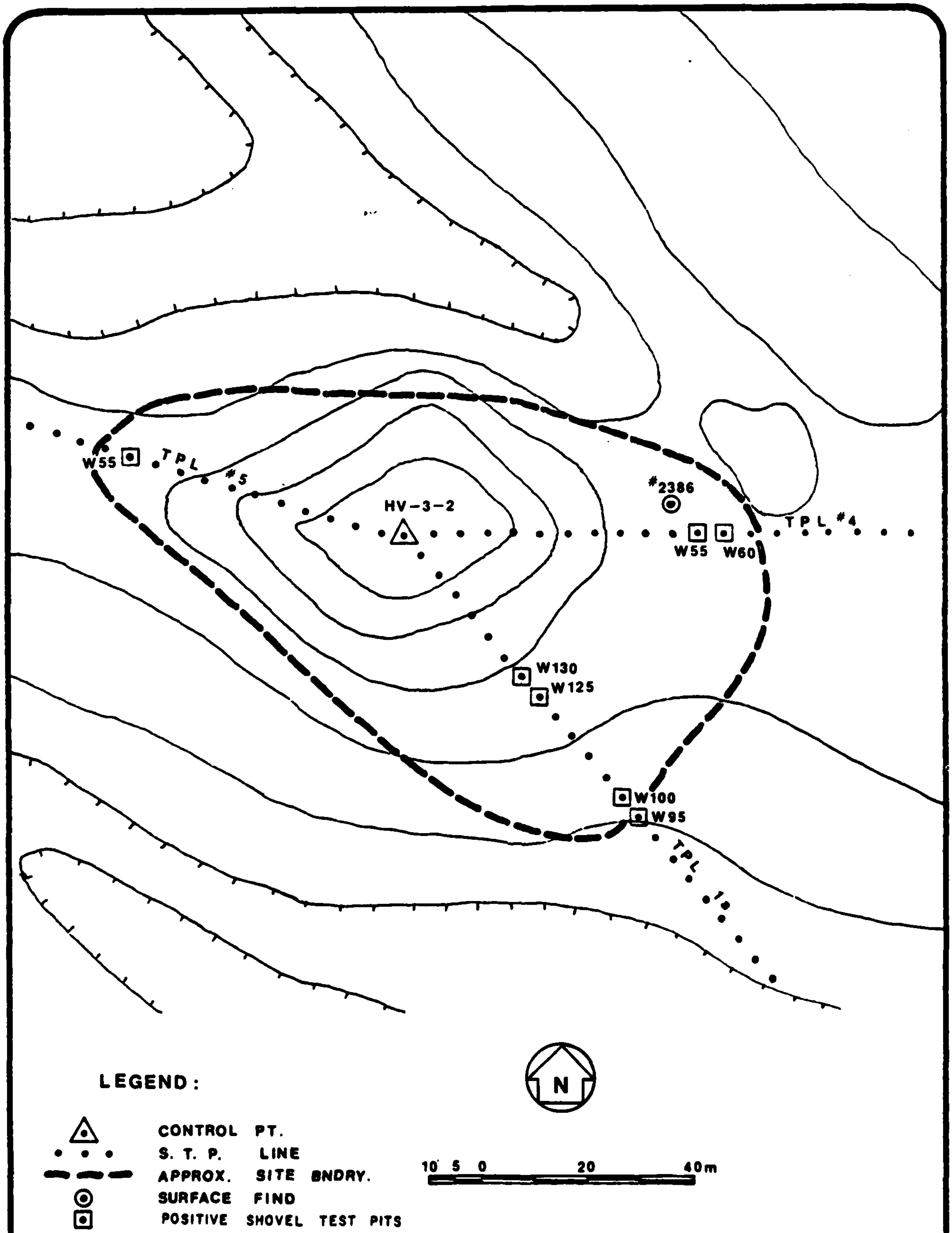

Figure 3-35. SBa-1684.

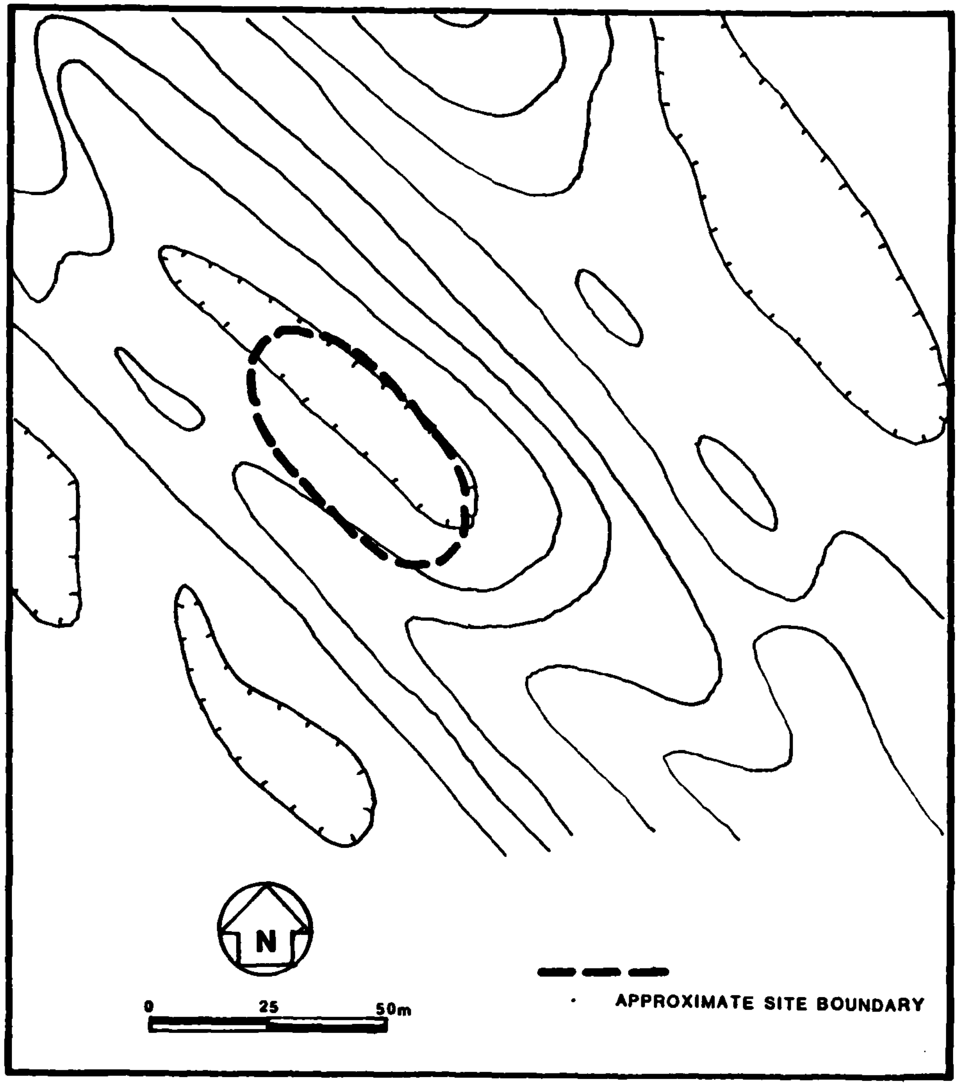

Figure 3-36a. SBa-1724.

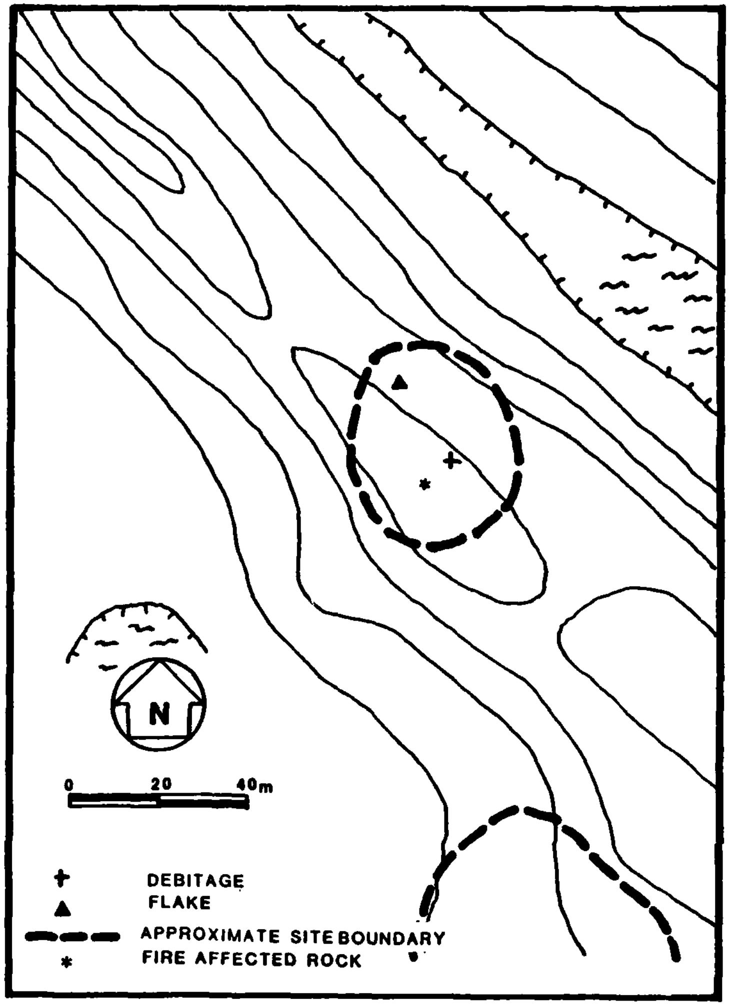

Figure 3-36b. SBa-1725.

SBa-1726 (Figure 3-37)

Immediate Environmental Context: The site is on a high dune ridge overlooking the recorded location of SBa-577 100 m to the northeast. Soils are loose dune sand semistabilized by coastal dune scrub. A very large wetland is located 50 m away in the swale to the north.

Gross Site Characteristics: The site is a small sparse scatter of relatively large chert flakes over a surface area of approximately 2,400 m^2 (40 m east-west and 60 m north-south). Its depth is unknown.

Description of Investigations: Artifacts were seen and mapped at the site's location by HDR crews during their survey of the Eastern Shelter road alignments in 1980. The site was subsequently recorded by CCP.

SBa-1174 (Figures 3-38 and 3-39)

Field work was conducted at SBa-1174 by HDR and later by CCP. Survey and excavations were carried out by HDR in advance of the construction of the 69 KV power line through the site. CCP conducted investigations in response to extensive damage to the site caused by the unsuccessful attempt by the base civil engineers to remove a large eucalyptus tree with a bulldozer.

Immediate Environmental Context: SBa-1174 is situated approximately 8 km inland from the Pacific Ocean on top of the land form delineating the eastern boundary of the San Antonio Terrace. This area lies beyond the eastern margin of the terrace dunelands and differs markedly in its physiography in comparison to the other portions of the project area. The ridge system associated with SBa-1174 drains north into Schuman Canyon and south into San Antonio Creek forming, respectively, the northern and southern boundaries of the San Antonio Terrace study area. Soils in the vicinity are sand and clay loams. Indigenous vegetation consists primarily of oak woodland and associated communities of chaparral. Riparian species are found along the intermittent stream course located to the west of the site.

Gross Site Characteristics: SBa-1174 is a multicomponent site containing both prehistoric and historic occupational episodes. An adobe ruin is situated approximately 20 m northwest of the area disturbed by the attempt to remove the large eucalyptus tree. Historic materials found in association with the adobe and the tree area are estimated to date from ca. 1850 to ca. 1930 (see Chapter 9).

An additional historic resource is located on the west side of the road bisecting the site, approximately 30 m west of the adobe ruin. Recorded as SBa-1175 by HDR in May 1980, the site consists of a collapsed frame structure surrounded by remnants of historic trash that date to the 1930s. Map 24 in Appendix II shows a water well in the vicinity that may have been associated with the wooden structure.

Prehistoric surface indicators consist, for the most part, of chipped stone flakes scattered over an area of approximately 2,000 m^2. Prehistoric materials are also visible in road cuts to depths of about 80 cm. Shellfish

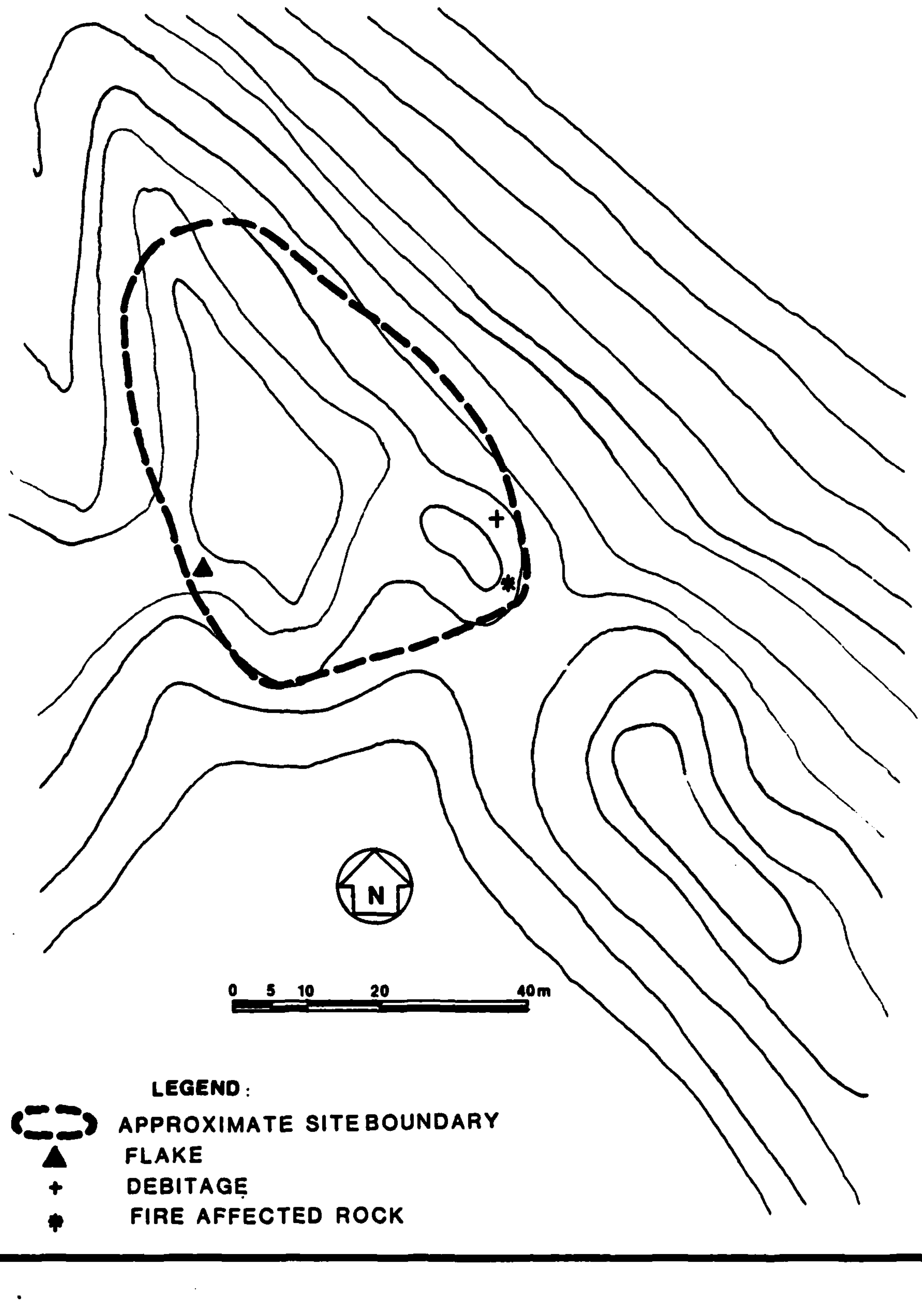

Figure 3-37. SBa-1726.

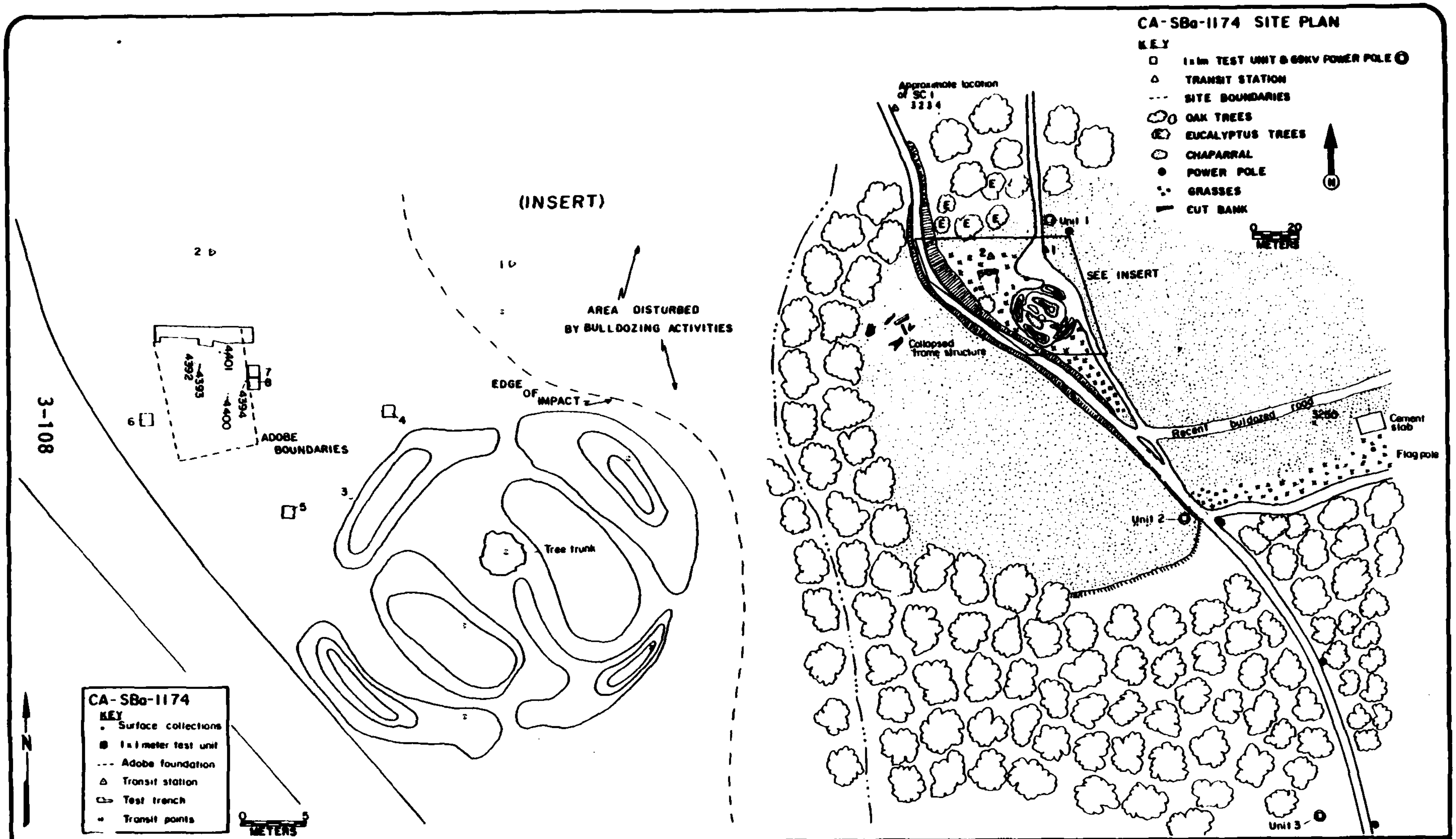

Figure 3-38. SBa-1174 Site Plan.

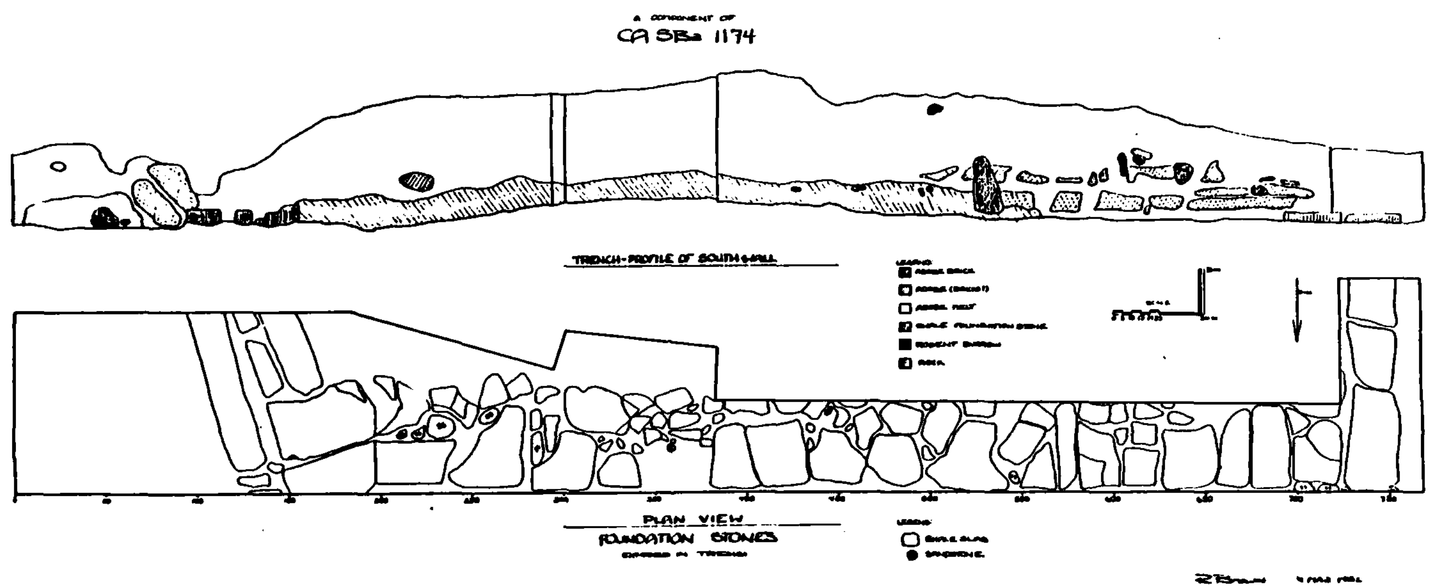

Figure 3-39. SBa-1174: Historic Components.

remains (Mytilus sp., Haliotis sp., and Tivila sp.) were found on the surface in the vicinity of the collapsed frame structure; these materials may be in an historic context.

Subsurface testing at SBa-1174 in support of the 69 KV power line project revealed prehistoric chipped stone flakes to a depth of 150 cm. Four chipped tools were recovered. Historic and prehistoric constituents were mixed throughout most of the upper 80 cm of the deposit.

Description of the Investigations: CCP's survey of the 69 KV power line route was described in a preceding section of this chapter and will not be repeated here. A summary of CCP's work specific to SBa-1174 is provided below.

CCP excavated three 1 m x 1 m test units to depths ranging from 80 cm to 150 cm at proposed pole emplacement locations within SBa-1174. Unit 1 was excavated to a depth of 120 cm and dry screened. Unit 2 was taken down to a depth of 150 cm (the unit was closed for safety reasons) and two STPs were placed in the bottom of the unit to a depth of 80 cm below the closing level. The unit was dry screened to Level 5, and the remainder of the levels was wet screened. Unit 3 was excavated to a depth of 100 cm and one STP was placed in the bottom of the unit to a depth of 35 cm below the closing level. Water was hit at 135 cm. All soils were screened through 1/16 inch mesh.

Pole emplacements for the 69 KV power line were monitored by VTN archaeologists in June 1981; no cultural materials were observed.

A second phase of field investigations was authorized by the COE in response to the considerable damage caused by the attempt to remove a large eucaplytus tree approximately 29 m southeast of the adobe ruin. A large pit measuring approximately 15 m across and several meters deep was excavated by a bulldozer, and the surface of the site was damaged by the heavy equipment.

CCP's initial instructions were to collect the materials exposed in the bulldozer excavation and to monitor the backfilling of the pit. After careful inspection of the artifactual materials exposed and in consultation with principal investigator Glassow, COE archaeologist Farrell, and monitoring archaeologist Spanne (VTN), it was decided that appropriate mitigation would include the collection of cultural material exposed on the surface of the disturbed area, the screening of several cubic meters of the backdirt to collect a sample of cultural material from the damaged matrix, and the excavation of controlled units to establish stratigraphic profiles to aid in comparing the damaged to the intact deposits.

At the discretion of the field director, the sample matrix was screened through every available screen, whether 1/4 inch, 1/8 inch or 1/16 inch mesh. Screen size was of no real concern; the object was to collect as rapidly as possible the cultural materials. Materials collected from the surface were screened with the 1/8 inch mesh. Of the approximately 4 m^3 of soil screened, about 2.5 m^3 was passed through 1/4 inch mesh, 1 m^3 through 1/8 inch mesh, and 0.5 m^3 through 1/16 inch mesh. Recovered materials

were bagged and labeled in the field according to screen size. As the severe disturbance precluded any contextual provenience determination for any of the material collected from this area, the same lot number was assigned to all collections recovered from the impacted area. Carbon, fire affected rock, and gravel were noted as present but these materials were not collected.

A total of five 1 m x 1 m test units to depths ranging from 15 cm to 110 cm were excavated during the August and October phases of the project. Units were consecutively numbered 4 through 8 and were opened during the month of August. The excavation of Units 6, 7 and 8 was not completed until the October phase of the investigation. (Units 1, 2 and 3 were excavated during the testing of the power pole emplacement locations for the 69 KV Line Survey.)

All test units were placed at the discretion of the field director. Unit datums were established at the northwest corner of each test unit and unit locations were mapped with transit and stadia rod in relationship to the main site datum (Datum 1) or to Datum 2. Datum 2 was established so that the unit locations could be triangulated.

During the August phase of the project, units were excavated in arbitrary 10 cm levels. When excavations resumed in late October, however, time and fiscal constraints dictated that excavation proceed in arbitrary 20 cm levels. All soils excavated were passed through 1/8 inch mesh.

Twenty-one chipped stone tools, groundstone, shell, bone, and carbon and late nineteenth early twentieth century glass and ceramics were recovered during the two phases of CCP's investigations.

Based upon the location of the adobe feature in Units 7 and 8 and following consultation with historical archaeologist Julia Costello and the principal investigator, a trench was placed north of Unit 7 at what appeared to be the northeast corner of the adobe foundation. The trench was extended west through the mound to intersect the northwest corner of the foundation. Because the sole purpose of the trench was to establish the perimeter of the former adobe structure, no stratigraphic or provenience controls were maintained during excavation. The trench was excavated to the dressed foundation stones, which were then followed westerly along the north wall of the structure for a distance of 8 m until the north-west corner of the foundation was exposed. The trench reached a maximum depth of 65 cm to 70 cm at its center (the high point of the mound) decreasing to 30 to 35 cm at the east and west ends respectively. The width ranged from 1 m at the east end to 50 cm, beginning from the midpoint and extending to the west end. Plan and profile views of the excavated trench are shown in Figure 3-39.

After reviewing materials recovered from the controlled excavations and from the sample screening of the tree disturbance area, Costello determined that enough data existed to date the adobe (see Chapter 9), and the field crew therefore was instructed not to collect additional materials unless the items were prehistoric and diagnostic in nature.

Chapter 4

QUATERNARY GEOLOGY AND SOILS OF THE STUDY AREA

INTRODUCTION

The Vandenberg region is geologically and pedologically a very complex but highly interesting region, one of the most interesting in fact in the state. Several mid to possibly early Pleistocene geomorphic surfaces, both marine and terrestrial, are preserved in the Vandenberg area. Burton Mesa, for example, constitutes one of the broadest, most extensive marine-bevelled Pleistocene surfaces in California, comparable in expanse and preservation--and possibly age--with the Linda Vista surface in the San Diego area. Younger, mainly fluvial terraces also occur along the rivers and streams in the region. These terraces together with various bedrock surfaces were blanketed several times during the Quaternary with sheets of ocean-derived dune sand. Soils have formed on this dune-terrace complex, some of which are extremely well developed. Such soils include the Tangair-Narlon Series, which resemble the Carlsbad (Chesterton) soils of the San Diego-Carlsbad area, the Green Mountain soils of San Miguel and Santa Rosa Islands, and the Arnold Series in the Cambria area to the north. Like Vandenberg, each of the above areas also has (or had, in the case of San Miguel [see Johnson 1972]) a relict population of conifers that tend to favor, or are competitively successful on, old dune landscapes.

For these and many other reasons, the writer found the Vandenberg area a fascinating and stimulating environment in which to do geological and soils research. It is hoped that this report conveys these perceptions.

Research Objectives

The objectives and goals of this research are to evaluate and document the late Quaternary geology and soils of the San Antonio Creek and adjacent areas of Vandenberg Air Force Base, California. The work was designed and executed to provide baseline soils, geologic, and paleoecologic information that would contribute to our societal body of literature, and to augment archaeological work being done in the area. If achieved, such objectives will lead to a better understanding of the dimensions and rates of landscape change through time, and of the evolving prehistoric-historic human resources in the area.

Scope of Work and Methods

The research performed involved five phases. First, a general field reconnaissance and mapping program was conducted during which site specific problems of particular interest were identified. Second, investigations of those site specific problems were carried out; this included describing and collecting geologic and soil samples, and collecting tree cores for dating trees. Third, laboratory analyses of the samples and tree cores were performed, followed by an interpretation of the results. Fourth, institutional literature search and examination of previous work was carried out. Finally, all these data were re-analyzed and integrated, which led to the production of this report.

Fieldwork was carried out during June, July, and November 1982. A total of about seven weeks was spent driving and walking over Vandenberg Air Force Base. Mapping was done using black and white and false color air photos, and 5-foot interval contour maps (Strategic Air Command 1978). The area reconnaissanced includes South and North Vandenberg, San Miguelito Canyon, the Santa Ynez River oceanward of Lompoc, San Antonio Creek oceanward of Vandenberg Road (S-20), Purisima Ridge, Point Sal Beach and Ridge, Guadalupe Dunes, and the Betteravia-Casmalia area. However, aside from limited but detailed work done just outside the base boundary at the Signorelli Ranch north of San Miguelito Canyon Road (below and east of Tranquillon Peak), the focus of work was on the lower San Antonio Creek area of North Vandenberg. Natural geologic and soil exposures were described and sampled, soil pits were dug and sampled, elevations were determined by hand level and from close interval contour maps, trees were cored for tree ring age determinations, gopher mounds were analyzed for stone number and size measurements, and sand samples from the San Antonio dune field and beach were systematically collected and analyzed. Late in the summer field season, and again in late November 1982, detailed soils work was carried out in the San Antonio dune field.

Soils were described as recommended in the Soil Survey Manual (Soil Survey Staff 1951) where the following were noted: color, texture, structure, consistence, clay coatings, reaction, special features (e.g., fecal pellets, mottles, etc.), pores, roots, and numbers and thicknesses of horizons. Moist soil colors were determined by wetting and hand homogenizing the less than 2 mm fine fraction, using Munsell notations. Unless otherwise indicated, dry colors were noted from homogenized air dried samples passed through a 2 mm sieve.

Soil samples were collected at 10 cm depth increments, or at an increment determined beforehand to be narrow enough to fall completely within a given horizon. Samples were placed in labelled bags and shipped to the laboratory.

In the laboratory the samples were air dried, passed through a 2 mm sieve, and fractionated in a Soiltest splitter. Particle size analysis was carried out by the pipet method (Kilmer and Alexander 1940; Soil Survey Staff 1972). Pretreatment of samples involved removal of organic matter with

hydrogen peroxide, and dispersion with sodium hexametaphosphate and reciprocal shaking for 12 hours. The sand fraction (2.0 mm to 0.05 mm) was separated from the pretreated sample by wet sieving and computed as a weight percentage of the whole sample. Percentage of silt (0.05 mm to 0.002 mm) was calculated by subtracting the combined weight of the sand and pipetted clay from the total sample. Thin sections of iron-cemented sand concretions that were present in several soils were made, and these were micromorphologically analyzed using a petrographic microscope. Chemical analyses included pH (1:1 soil and water), cation exchange (sodium saturation-titration method), calculated percent base saturation, organic matter analysis (Walkley-Black method), phosphorus (weak and strong Bray), and soluble salts (Bouyoucos bridge); for these methods see Black (1965). Some age dating has been done at UCLA (C-14), and at the Illinois State Water Survey, Urbana (tree ring dating), and other dating is planned for 1984-1985 at the University of California at Santa Barbara (paleomagnetic dating), at the Illinois State Geological Survey, Urbana (C-14), and at the University of Arizona, Tucson (C-14). The results of the completed analyses are given in later appropriate sections.

Literature search was done at the University of California, Santa Barbara, Lompoc Historical Society, Santa Maria Historical Society, Office of the Vandenberg Base Historian, and the University of Illinois. Help was also sought from various local (Santa Barbara County) area residents and researchers.

GEOLOGY

Bedrock Geology

The bedrock geology of Vandenberg Air Force Base is summarized in two maps in Strategic Air Command (1978, sheet C-6a) which presumably was taken from Dibblee (1950). For this report these maps were modified and reproduced as Figure 4-1a, 4-1b, and 4-1c. The maps are referred to in the following and later sections of this report. For further information the reader is referred to Dibblee (1950), Woodring and others (1943) and Woodring and Bramlette (1950).

Stratigraphy and Structure: Most of North Vandenberg is underlain by easily erodable Sisquoc Formation rocks of lower Pliocene age, a white-weathering massive impure diatomite-diatomaceous marine shale, and the Monterey Formation of upper Miocene age, a hard laminated platy siliceous marine shale, with diatomite lenses. These rocks form structures that are part of the east-west trending Transverse Ranges. The Transverse Ranges consist of folded rocks of mainly Tertiary age in an area of geologically active north-south compression (crustal shortening) due to lithospheric plate interactions along the San Andreas Fault (Anderson 1976). Owing to the north-south compression, the geologic structures (anticlines, synclines, etc.) are east-west trending across Vandenberg. The structures and regional rock types promote oil reservoirs which are being tapped by several wells on the

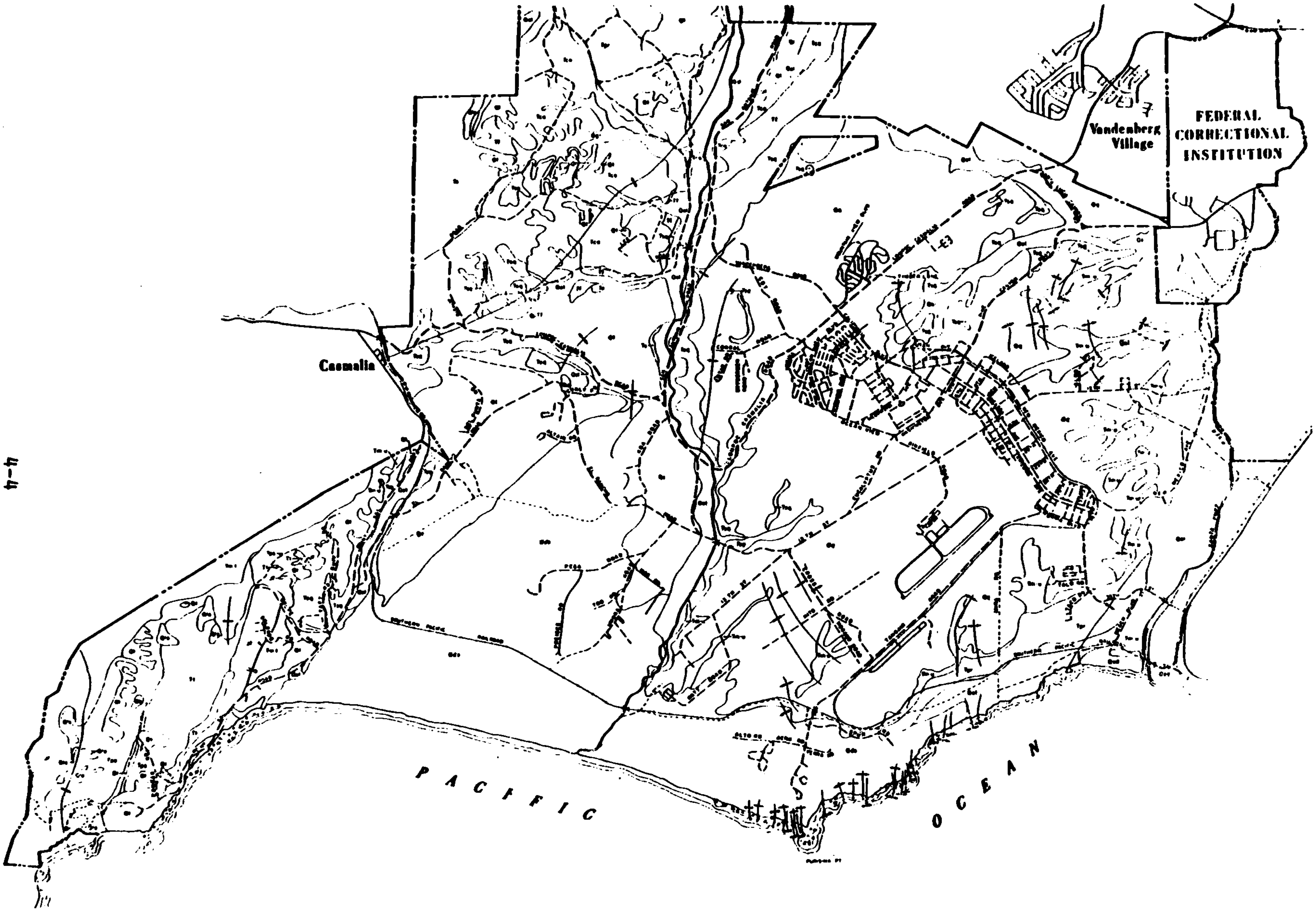

Figure 4-1a. Bedrock Geology of Vandenberg Air Force Base (Strategic Air Command, 1978).

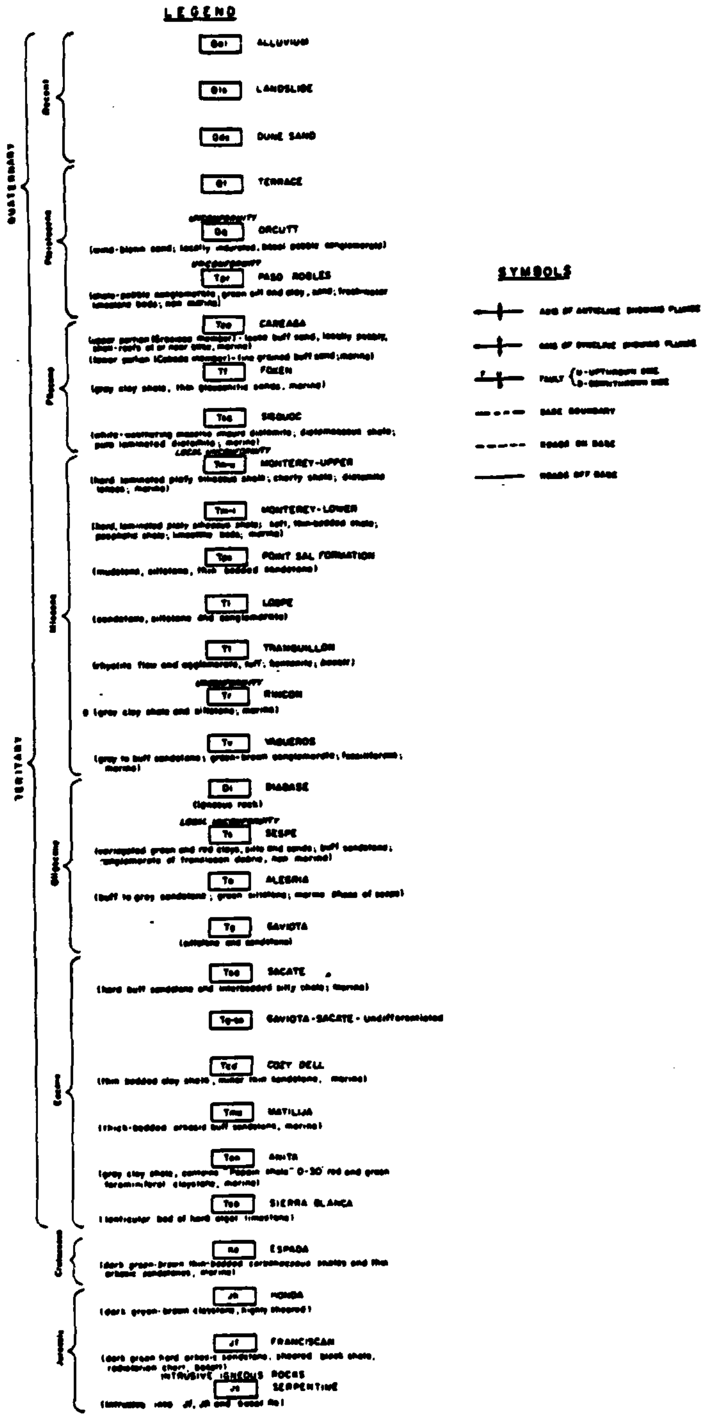

Figure 4-1b. Bedrock Geology of Vandenberg Air Force Base (Strategic Air Command, 1978).

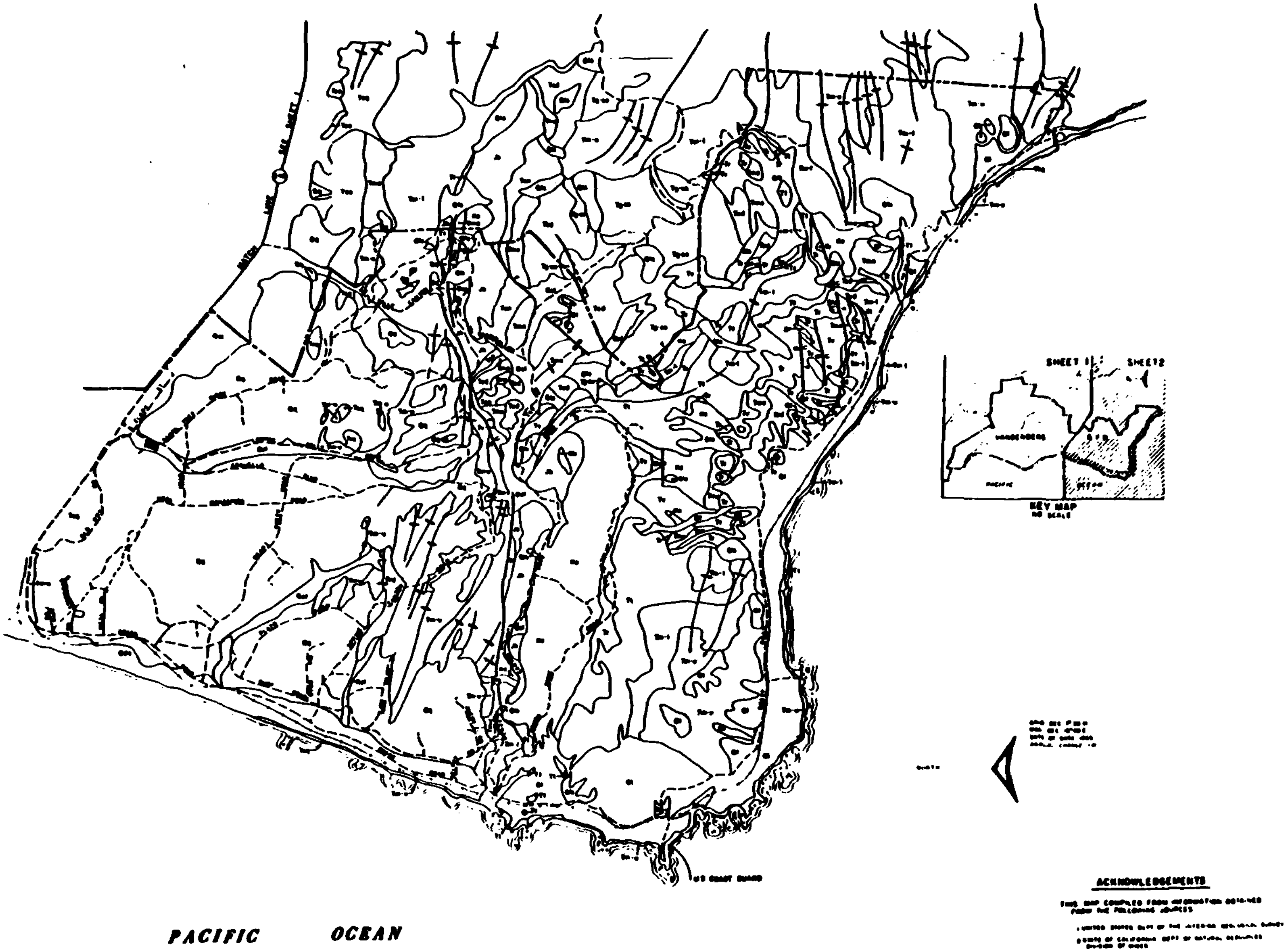

Figure 4-1c. Bedrock Geology of Vandenberg Air Force Base (Strategic Air Command, 1978).

Surficial Geology and Depth to Bedrock: The surficial geology and, to a limited extent, depth to bedrock are also contained in Strategic Air Command (1978, Sheet C-6). The latter contains the locations of 152 soil bore holes that were drilled across Vandenberg, together with generalized logs. This information has been reproduced for this report as Figure 4-2a, 4-2b, 4-2c, 4-2d, and 4-2e. Reference to this figure will be made later.

Marine Terraces

Burton Mesa: Marine terraces consisting of bevelled bedrock platforms veneered with marine gravels buried under a terrestrial cover of alluvium and eolian sands are responsible for the mesa-like character of the surfaces that dominate much of the landscape of Vandenberg; Burton Mesa is the most striking example of such a polygenetic landform. The broad, buried, gently sloping marine platform of Burton Mesa stretches from the ocean near Purisima Point, where it is subaerially exposed in a quarry about 120 m west of the Southern Pacific tracks of Tangair, eastward beyond the main base facilities where it is visible along the mesa edge at Lake Canyon. It is also visible along the north side of the Santa Ynez River Valley north and west of Lompoc, and is probably correlative with the bedrock surface visible on the south side of the river near its mouth. Burton Mesa extends east from the ocean at least as far as Santa Lucia Canyon, and perhaps Purisima Canyon where it abuts Purisima Ridge north of Lompoc. Because, however, the terrestrial cover appreciably thickens to the east towards Purisima ridge the eastward limit of the buried marine platform is uncertain, and it is not known whether it consists of one continuous platform or, as is more likely, several platforms and risers.

The marine origin of the bedrock platform is proved by the presence of burrows of rock-boring marine clams (pholads) on the bevelled bedrock surface (noted earlier by Arnold and Anderson [1907]; see Plate 1). Such burrows occur at many places, for example at the above mentioned bedrock quarry just west of Tangair, at the roadcut where 13th Street intersects the southern edge of Burton Mesa on the north side of Santa Ynez River, at the north edge of Burton Mesa overlooking San Antonio Creek just east of El Rancho Road (where the footpath intersects the mesa edge), and in the roadcut where Cross Road intersects Canada Juan Pedro about 1 km southeast of El Rancho Road (13th St.).

The age of the bedrock marine platform of Burton Mesa is unknown, but it is probably middle to late Pleistocene. Nothing in the way of calcareous marine shells or unfossilized bone was found that could be dated by amino acid or Uranium series techniques (the writer, however, is optimistic that further search would ultimately yield success). The shoreline angle (or angles?) present doubtlessly correlate with one or more of the high sea level stands of the Quaternary, with likely candidates being high sea stands associated with oxygen isotope stages 7, 9, 11 or 13 (Shackelton and Opdyke 1973).

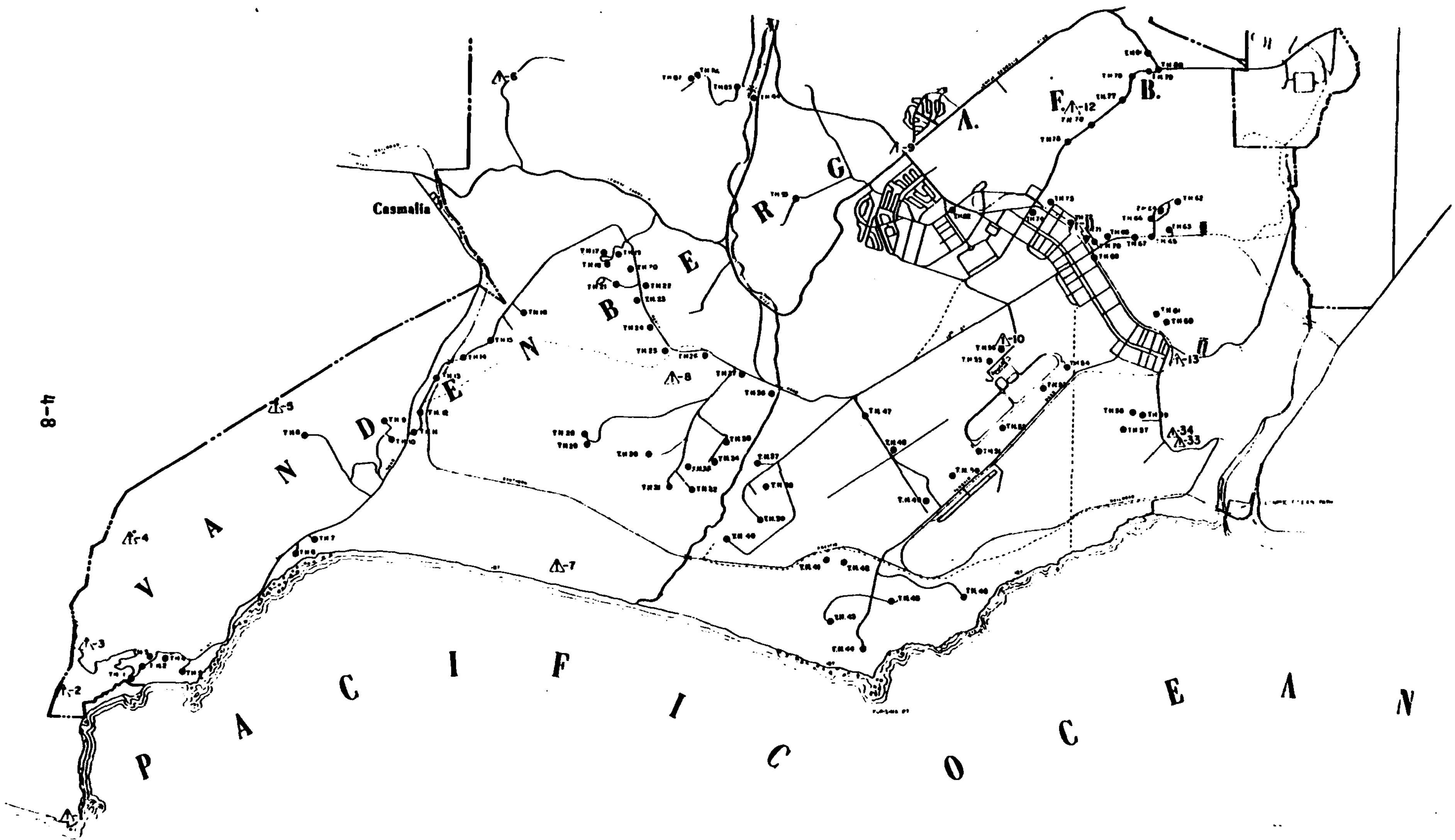

Figure 4-2a. Location Map of Soil Bore Holes and Generalized Logs.

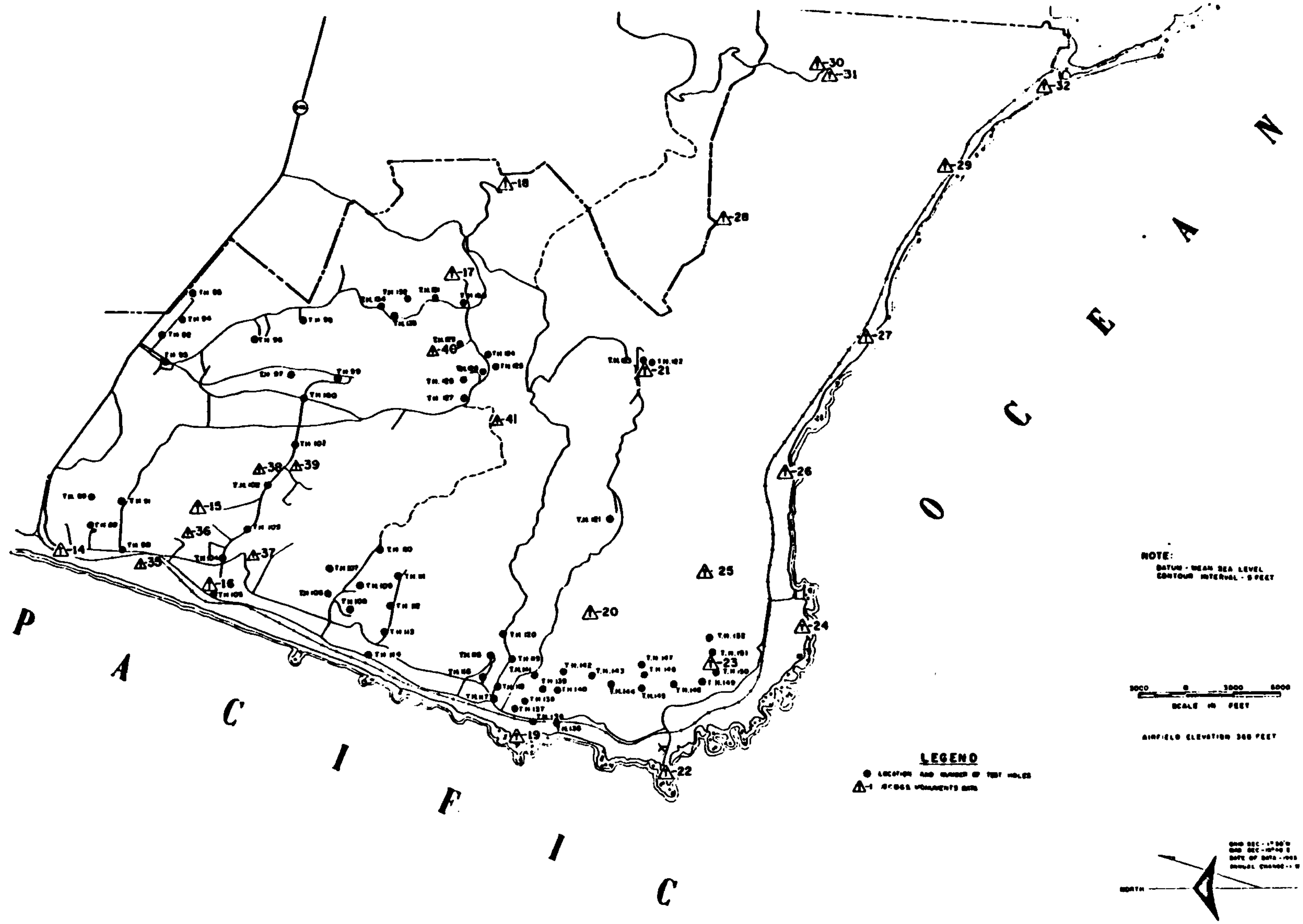

Figure 4-2b. Location Map of Soil Bore Holes and Generalized Logs.

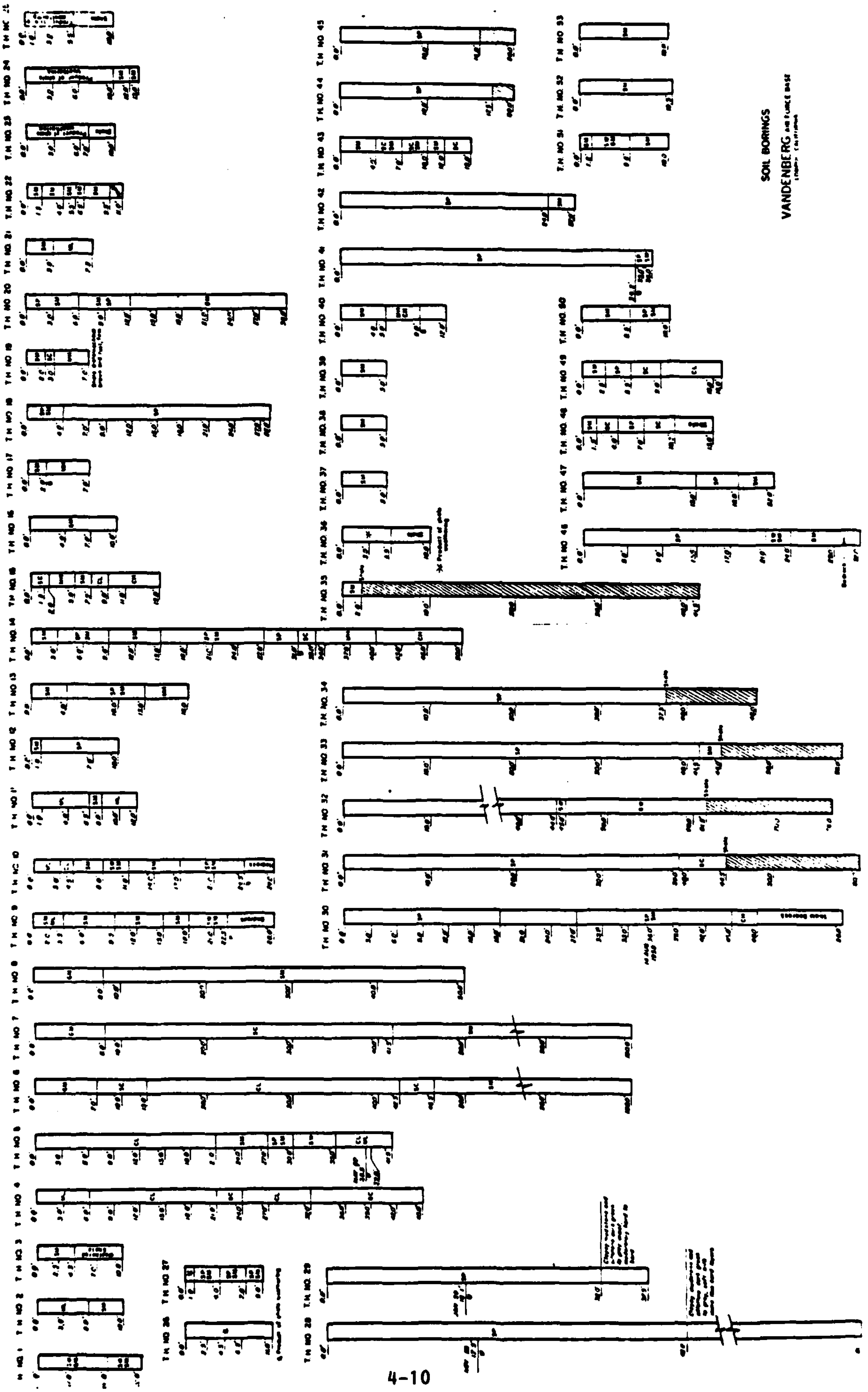

Figure 4-2c. Soil Borings.

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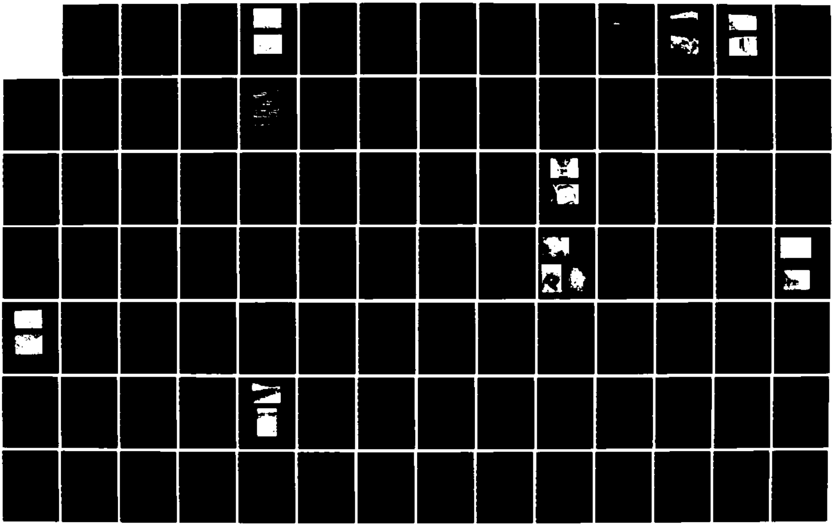

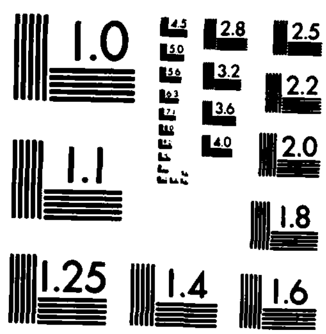

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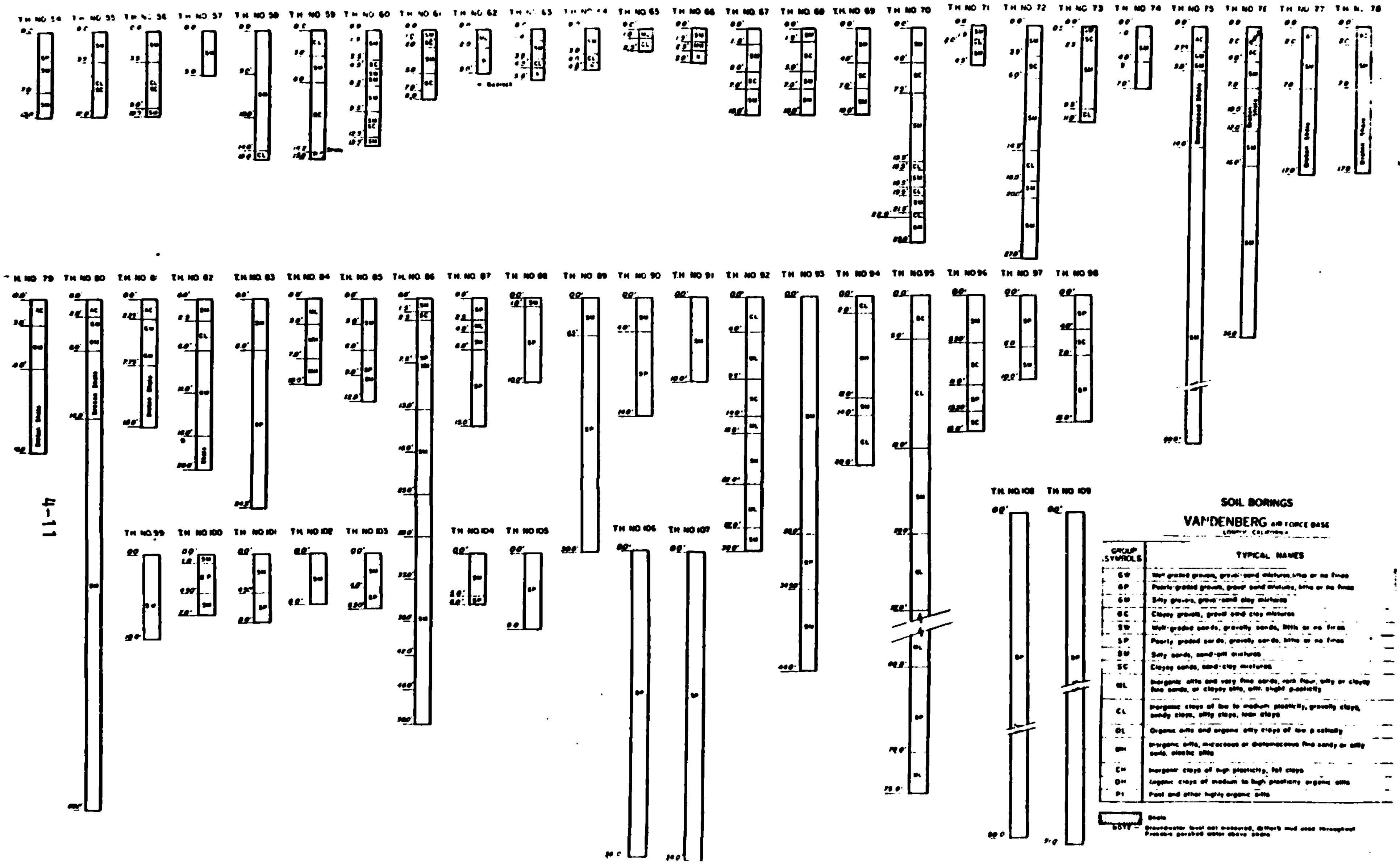


Figure 4-2d. Soil Borings.

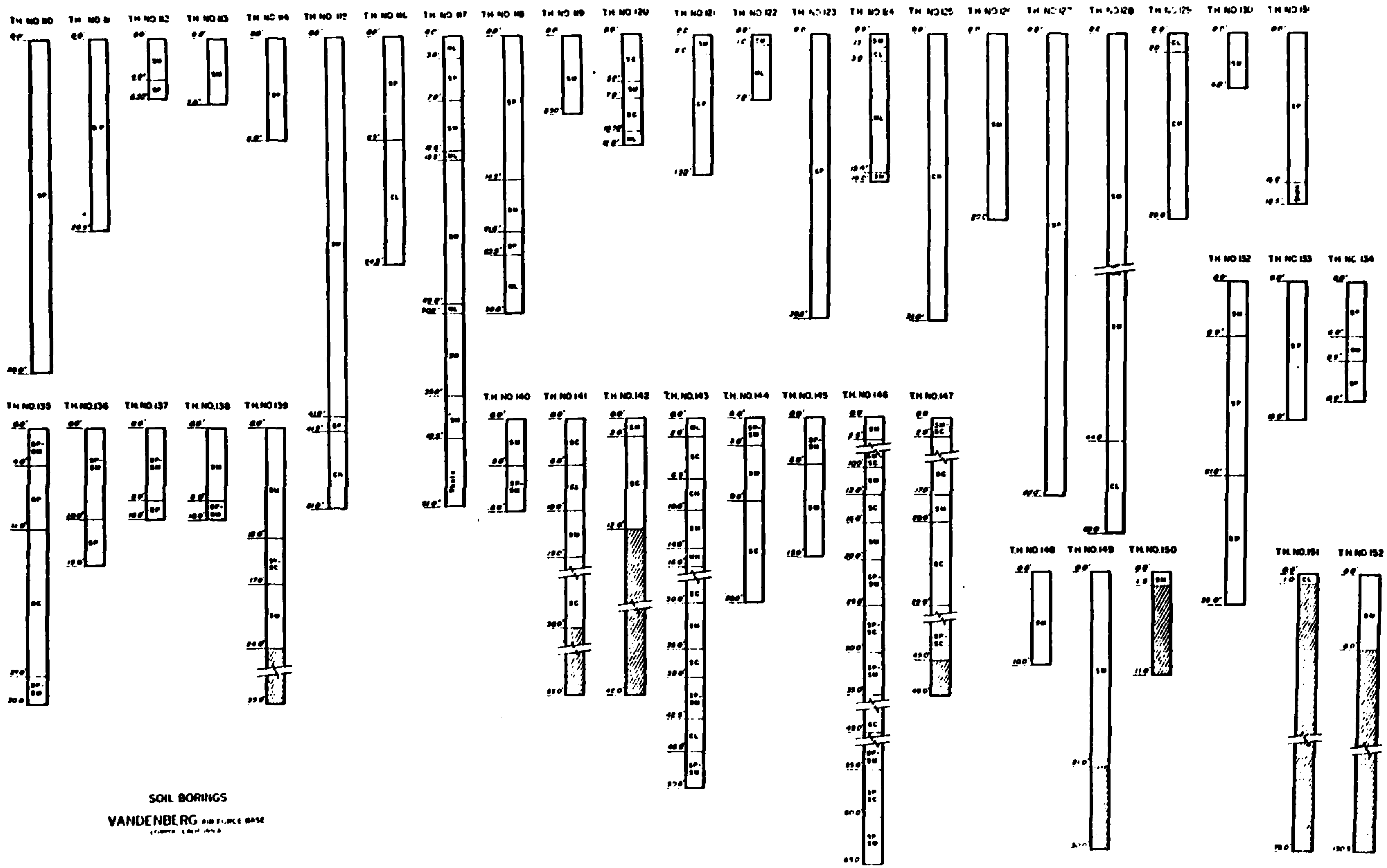
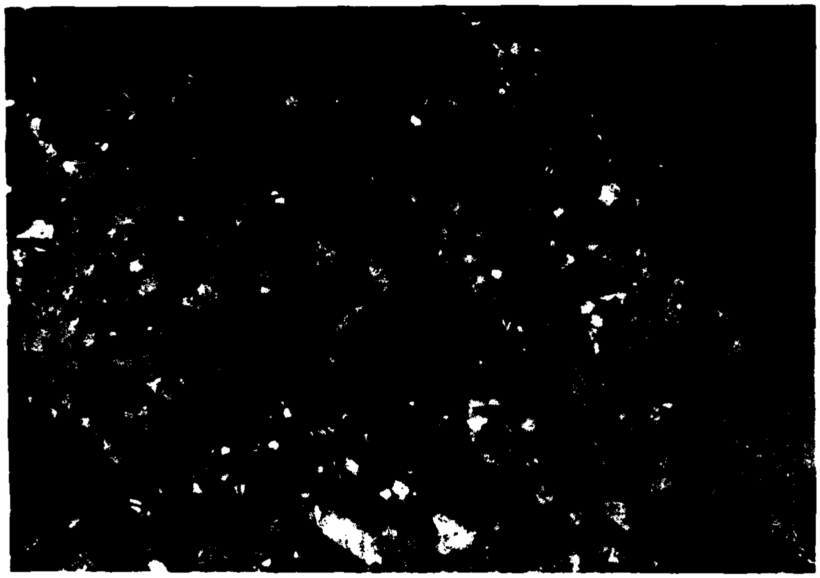


Figure 4-2e. Soil Borings.



a

b

Plate 1. a. Marine clam (Pholad) bored holes at intersection of Cross Road and Canada Juan Pedro, north Vandenberg.

b. Gopher burrows in "window" immediately north northeast of Marshallia Ranch dump.

Seven surface slope gradients of Burton Mesa were calculated and show an average of 10.2 m/km (53.8 feet/miles) or 1.0 percent slopes (measurements were made near the base airport and near the north end of the mesa, determined from 5 feet contours of Sheet 23, Strategic Air Command 1978, and from 20 feet contours of 7.5 minute Casmalia and Surf Quadrangle maps).

The broad expanse of Burton Mesa indicates that a significant inland marine incursion must have occurred during the planation of the marine platform (or platforms, if multiple). Probably this marine incursion and platform planation episode was assisted by the local occurrence of the Sisquoc Formation, which is the principal bedrock unit of north Vandenberg (Sheet C-6a, Strategic Air Command 1978). The Sisquoc is an exceedingly incompetent and easily erodable shale with local abundances of soft diatomaceous earth. Had a more competent rock type been present Burton Mesa probably would not have formed to its present areal extent.

The question that next logically follows is, if the bedrock is so easily eroded why is Burton Mesa so well preserved? Two non-mutually exclusive hypotheses are advanced to account for the good preservation of Burton Mesa. One is that the blanket of dune sands which cover it provide protection against erosion. Sand tends to act as a sponge for beating rains that soak in rather than run off as overland flow. The potential for erosion is thus greatly reduced. The other hypothesis is that the soils which formed in the cover dunes and underlying marine sands and gravels protect the mesa from erosion. These are the Tangair and Narlon series soils that have developed varying degrees of hardpans consisting of secondarily accumulated silica and/or iron in their profiles. The silica enriched hardpans are called durapans and tend to be very resistant to erosion.

Attention was first called to hardpan soils in the region by Louderback (1912) who referred to them as "pseudostratified" units. The reader may recall in the Introduction that comparisons were made between the Quaternary geology and soils of Vandenberg and the Linda Vista terrace in the San Diego area. The latter terrace, probably of middle to early Pleistocene age, also owes its good preservation in part to the presence of durapans.

Multiple Marine Platforms and Casmalia Geomorphic Surface: It is possible, if not probable, that the marine bevelled surface under Burton Mesa consists of more than one terrace platform. This inference is based on the observation that multiple marine platforms are the rule along other stretches of the coast. In this regard, Woodring and others (1943) and Woodring and Bramlette (1950:124) identified five marine terraces at various elevations on Mount Lospe on North Vandenberg, the highest platform of which occurs at about 244 m (800 ft.).

Other direct evidence for multiple platforms in the area exists under the North Mesa portion of the Casmalia Geomorphic surface, (parts of the combined Qt_4, Qt_5, Qt_6 and Qt_7 surfaces of Figure 4-3). Well sorted sands and rounded gravels that contain a number of abraded silicified cetacean (whale) bones are exposed in a bedrock quarry at point MG on surface profile S-S' of Figure 4-4a and 4-4b. The bedrock rises immediately above the

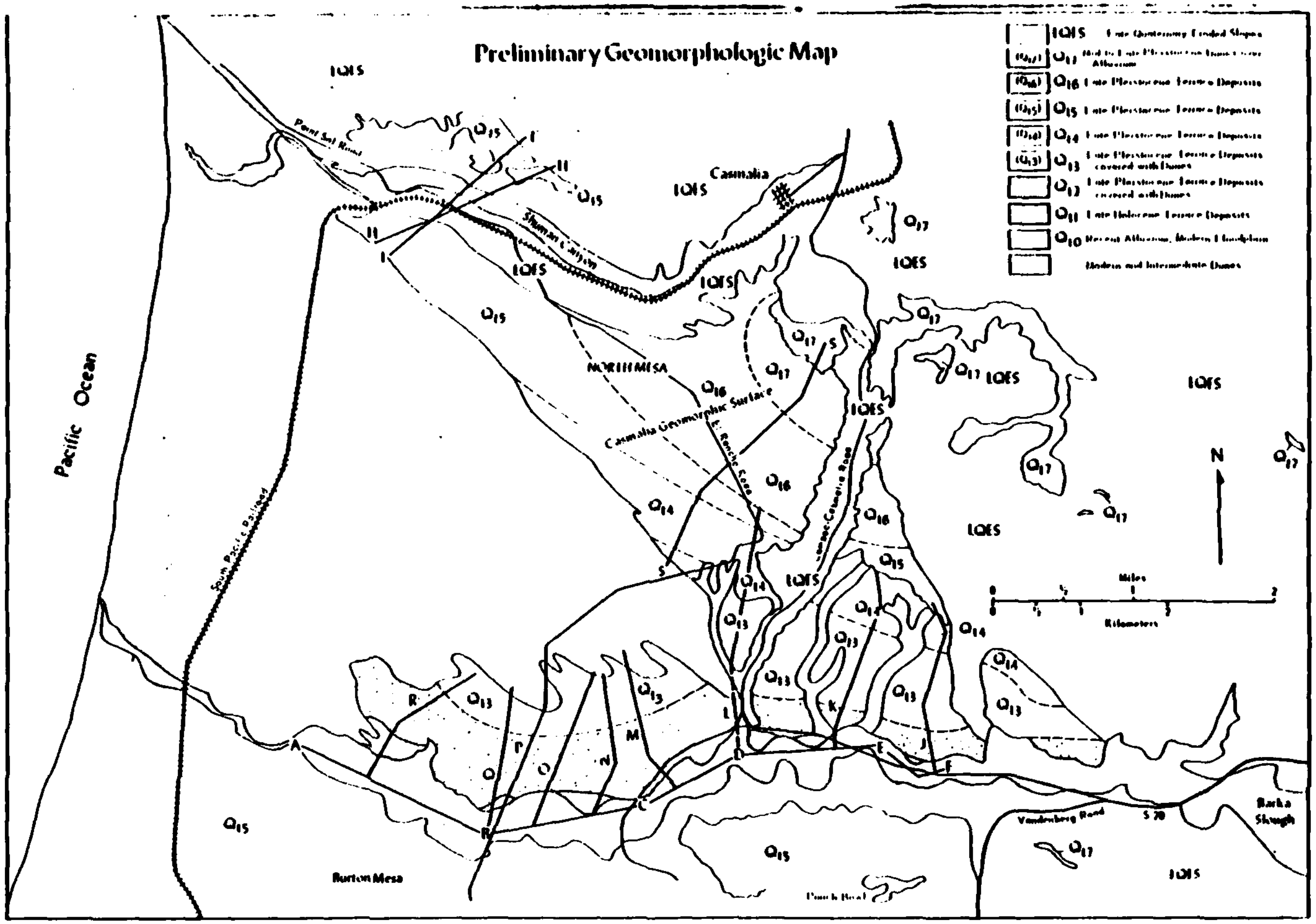


Figure 4-3. Provisional Geomorphic Map of the Lower San Antonio Creek Area, Vandenberg Air Force Base.

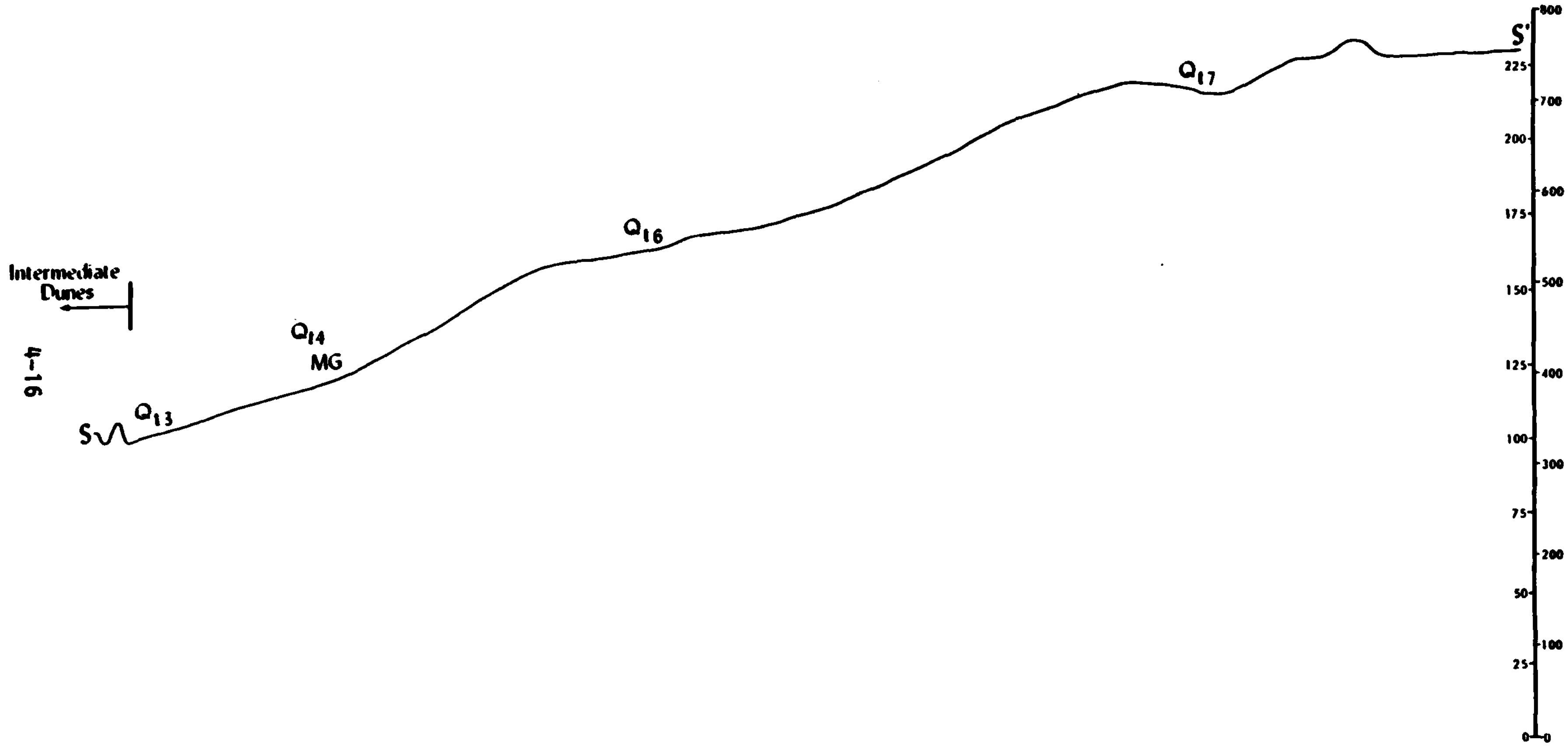


Figure 4-4a. Surface Profile S-S' Along Portion of Casmalia Geomorphic Surface North of Marshallia Ranch. Topographic map portion on which surface profile is shown in 4-4b (see Figure 4-3 for location S-S').

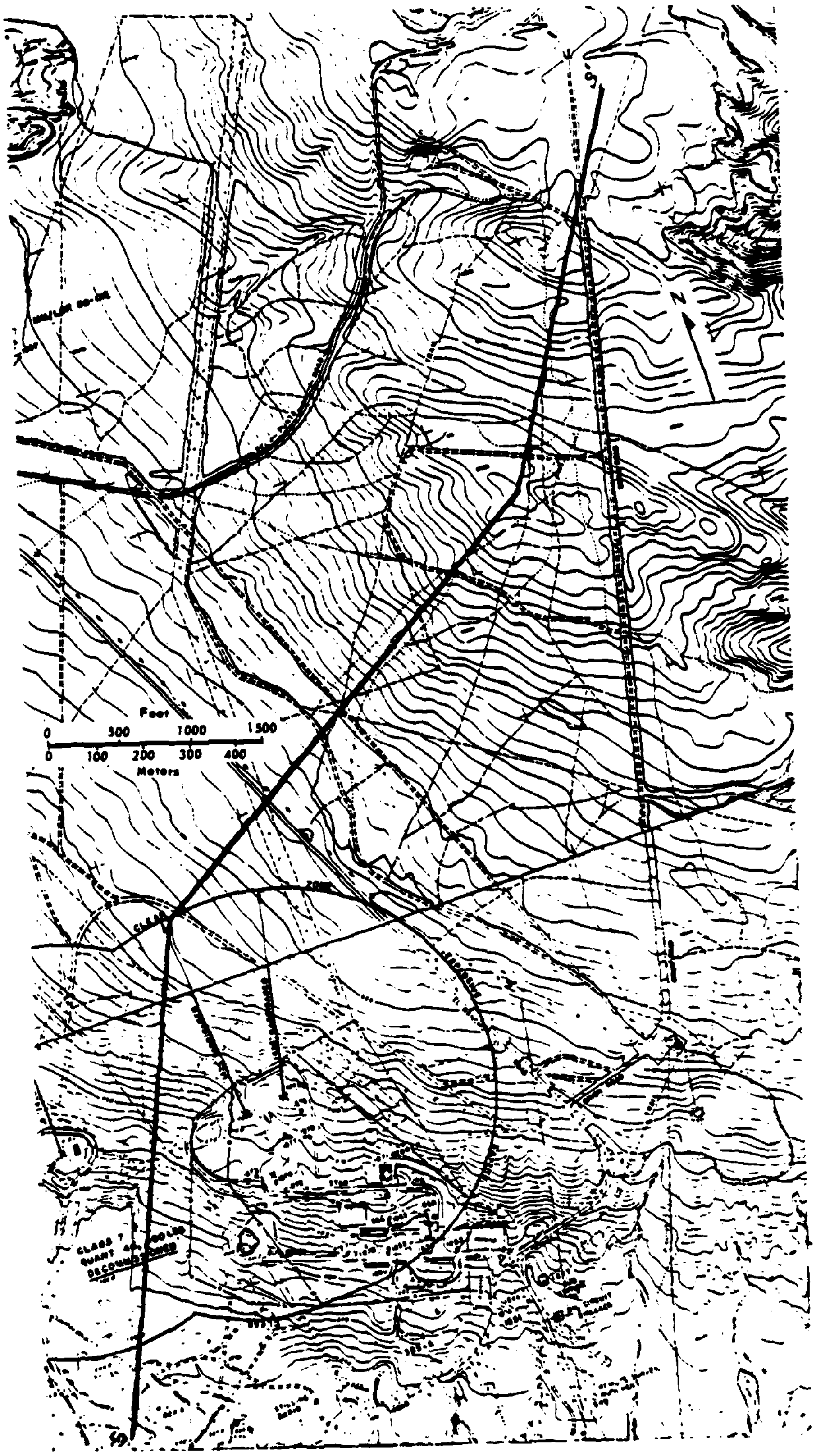


Figure 4-4b.

quarry and probably is a relict sea cliff above a nearby buried shoreline angle. A slight break in the surface profile at this point suggests the presence of a shoreline angle. Farther upslope on the profile at an elevation of roughly 172 m (565 feet) a much more prominent break in slope occurs, suggesting a second higher shoreline angle and platform (the surface has been mapped at Qt_6). Above this lies the marine platform that is exposed at the Caprock locality near the summit of the Lompoc-Casmalia Road, some 100 m south of its intersection with Bishop Road. Here, a bevelled marine platform with rock-boring clam burrows occurs at about 203 m (666 feet) elevation, which is considerably above the closest north edge of the Burton Mesa platform 2.6 km due south (Figure 4-5; Plates 2a and 2b).

In retrospect, a number of marine shoreline angles and probably associated platforms are present on North Vandenberg, several of which are associated with the Casmalia geomorphic surface on North Mesa. These marine terraces are correlated with stream terraces of the San Antonio Creek (Figure 4-5). One or more of these terraces may also correlate with the obscured marine platform(s) of Burton Mesa, although more detailed field work is needed to firmly clarify these relations.

Point Sal Terraces and Beachrock: At least two marine terraces were observed, about 1.8 km (1.1 mile) due east of Point Sal and, as mentioned, Woodring and Bramlette (1950) observed five terraces on nearby Mount Lospe. The lower one at Point Sal is well expressed along the small stretch of east-west directed coastline, and its foredge measured an average of 9.8 m (32 feet) above mean sea level (m.s.l.). The second terrace observed was either mostly eroded away or masked by hillslope colluvium, as it was visible only in several places. Its foredge measured 25.3 m (83 feet) above m.s.l. Though no shoreline angles were observed, the steepness of the cliffs above the terraces suggest that they are close to the measured foredge elevations. Marine shell samples were collected from both terraces, and amino acid dates on them are planned. Patches of beachrock (watertablerock) were present on both terrace platforms. Beachrock is generally a low to lower middle latitude carbonate rock, and to this writer's knowledge the Point Sal deposits mark its northernmost occurrence along the west coast of North America (Johnson 1972).

The two observed low marine terraces at Point Sal, plus those described by Woodring and Bramlette (1950) on Mount Lospe, are presumed to have correlatives in the main Vandenberg Base area, though this remains to be determined conclusively. In this writer's judgement, the most likely place to observe such correlates would be along the northern scarp, or edge of Burton Mesa along San Antonio Creek. (Time constraints did not allow detailed field work to be done in the area.)

Stream Terraces

Stream terraces were studied principally in the lower San Antonio Creek drainage basin west of Barka Slough. Various aspects of the hydrology and fluvial regime of San Antonio Creek have been described by O'Brian and

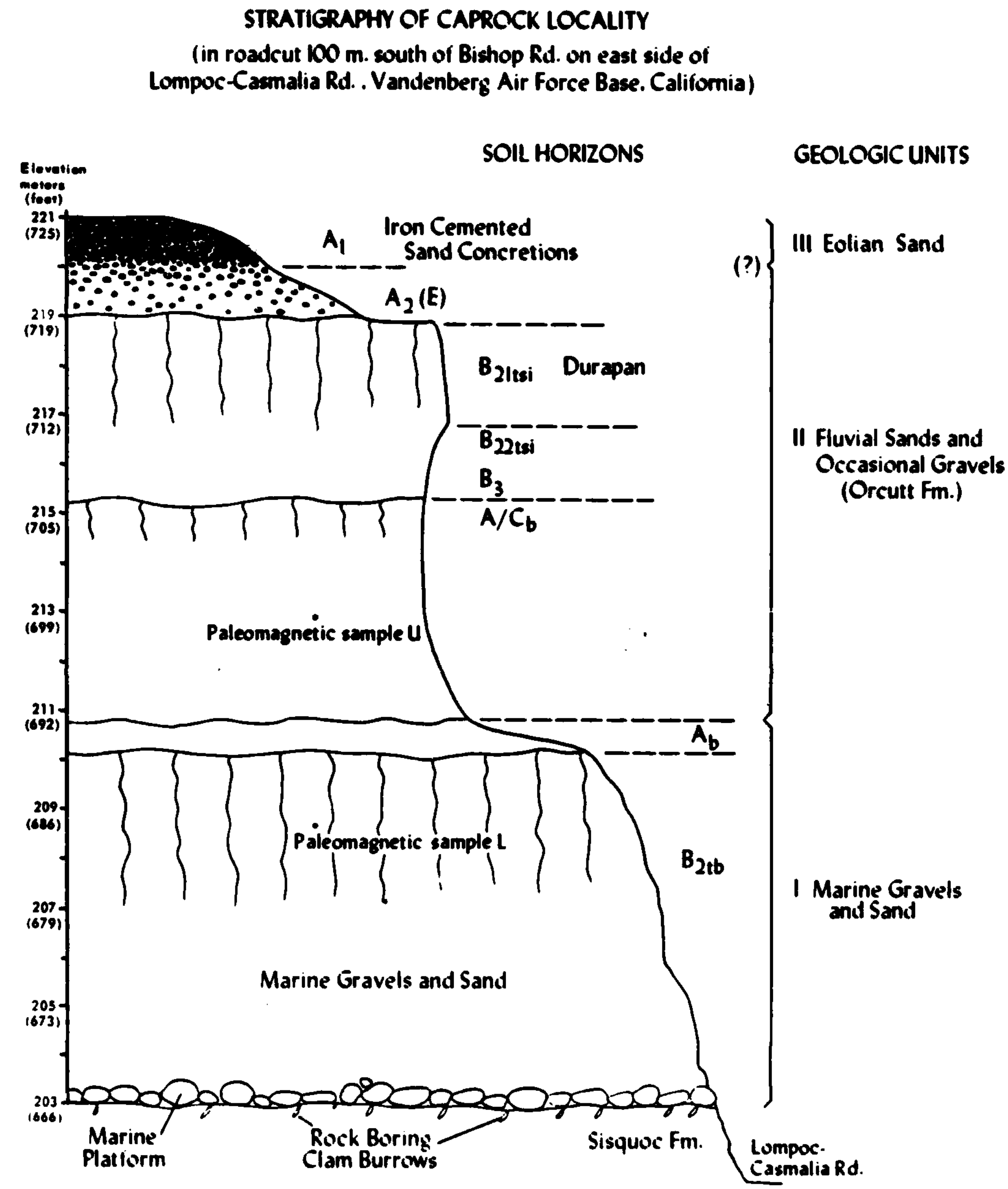


Figure 4-5. Stratigraphy of the Caprock Locality Near the Summit of the Casmalia Geomorphic Surface, Near Bishop Road and Lompoc-Casmalia Road Intersections.

a

b

Plate 2a. Ancient soil exposed at intersection of Bishop Road and Lompoc-Casmalia Road, near Caprock Locality.

a. Ledge is created by well developed durapan in the B horizon of the soil.

b. Ironstone concretions in the A horizons of the ancient soil.

a

b

Plate 2b. a. The mesa-forming and erosionally resistant durapan of the Qt_7 surface is apparent.

b. Close up of caprock durapan shown in A. Both photos taken near Caprock Locality.

others (1981), Mallory (1980), Descheneaux (1975), Hutchinson (1980), Lamb (1980), Muir (1964), and Waananen and Crippen (1977). Roberts (1982) has reviewed and summarized part of this history, and the reader is advised to consult Appendix II for overview considerations.

A coordinated topographic map-field work effort produced valuable information on the fluvial system of San Antonio Creek. Maps with contour intervals of 5 feet (1.5 m) permitted the generation of high resolution surface profiles of land adjacent to San Antonio Creek. A total of nine profiles were determined along the creek from upstream near Grant Road, to MOD Lake downstream (Figure 4-6). The south ends of these cross sections were terminated on San Antonio Creek flood plain. The present gradient of San Antonio Creek was calculated in five straight line segments (Table 1), and plotted on graph paper scaled to horizontal distance. The nine surface profiles were then plotted along this gradient, again scaled to the same horizontal distance to give a reasonably realistic visual rendition of the terraces to one another. The result is shown in Figure 4-6. This figure shows the distance and vertical relationships of the preserved terrace remnants not only to one another, but also to the present floodplain and to possible marine terrace correlations on North Mesa. The inferred elevations of the terrace remnants were then plotted by scaled distance and elevation on graph paper. To these data were added the elevations of other stream terrace segments, inferred from maps and field work, that did not fall on the surface profiles (Figure 4-7). Provisional correlations were then made as shown on Figures 4-3, 4-6, and 4-7.

Table 4-1: San Antonio Creek Floodplain Gradients[1]

Floodplain[1] Segment	Vertical Distance ft.(m)	Horizontal Distance ft.(m)	Percent Gradient	Feet per Mile (m/km)
A-B	7(2.1)	76800(2340.9)	0.09	4.8/1 mi (0/9/km)
B-C	20(6.1)	5760(1755.6)	0.35	18.2/1 mi (3.5/km)
C-D	31(9.5)	4160(1268.0)	0.75	39.2/1 mi (7.4/km)
D-E	39(11.9)	4800(1463.0)	0.81	42.9/1 mi (8.1/km)
E-F	20(6.1)	2800(853.4)	0.71	37/1 mi (7/km)
TOTAL	117(35.7)	25200(7681.0)	0.46	24.4/1 mi (15.2/km)

[1]Measured in five straight line segments (see Figure 4-7). These data calculated from sheets 19, 20, 24, and 25 (5 ft. interval contour maps) of Section C-1, Volume 1, Strategic Air Command (1979).

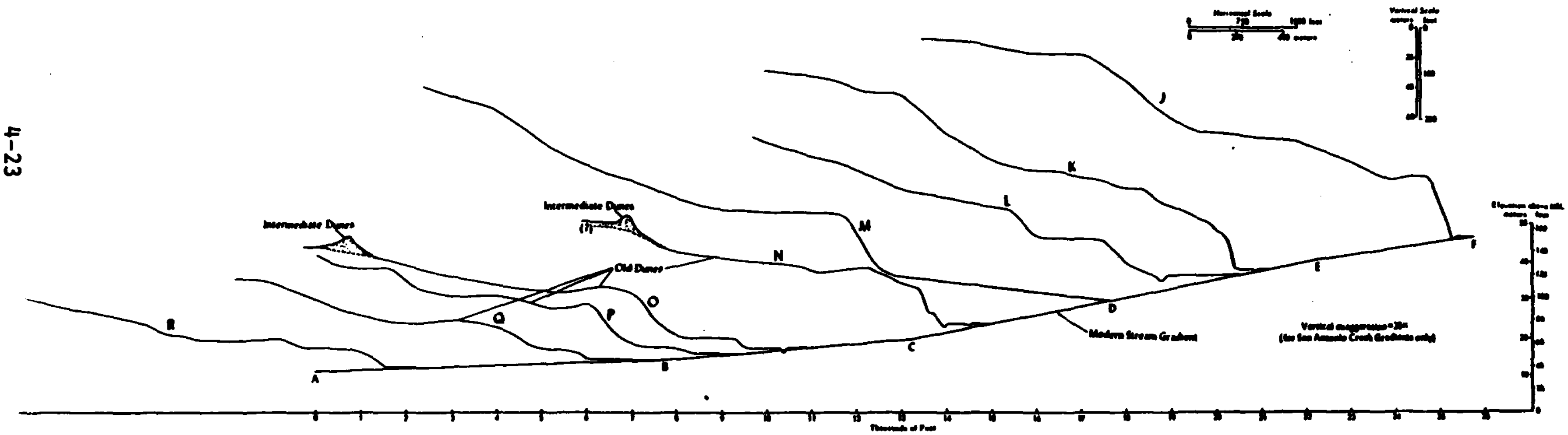


Figure 4-6. Surface Profiles Drawn to San Antonio Creek Gradient, and Scaled in Horizontal Distance (see text for explanation).

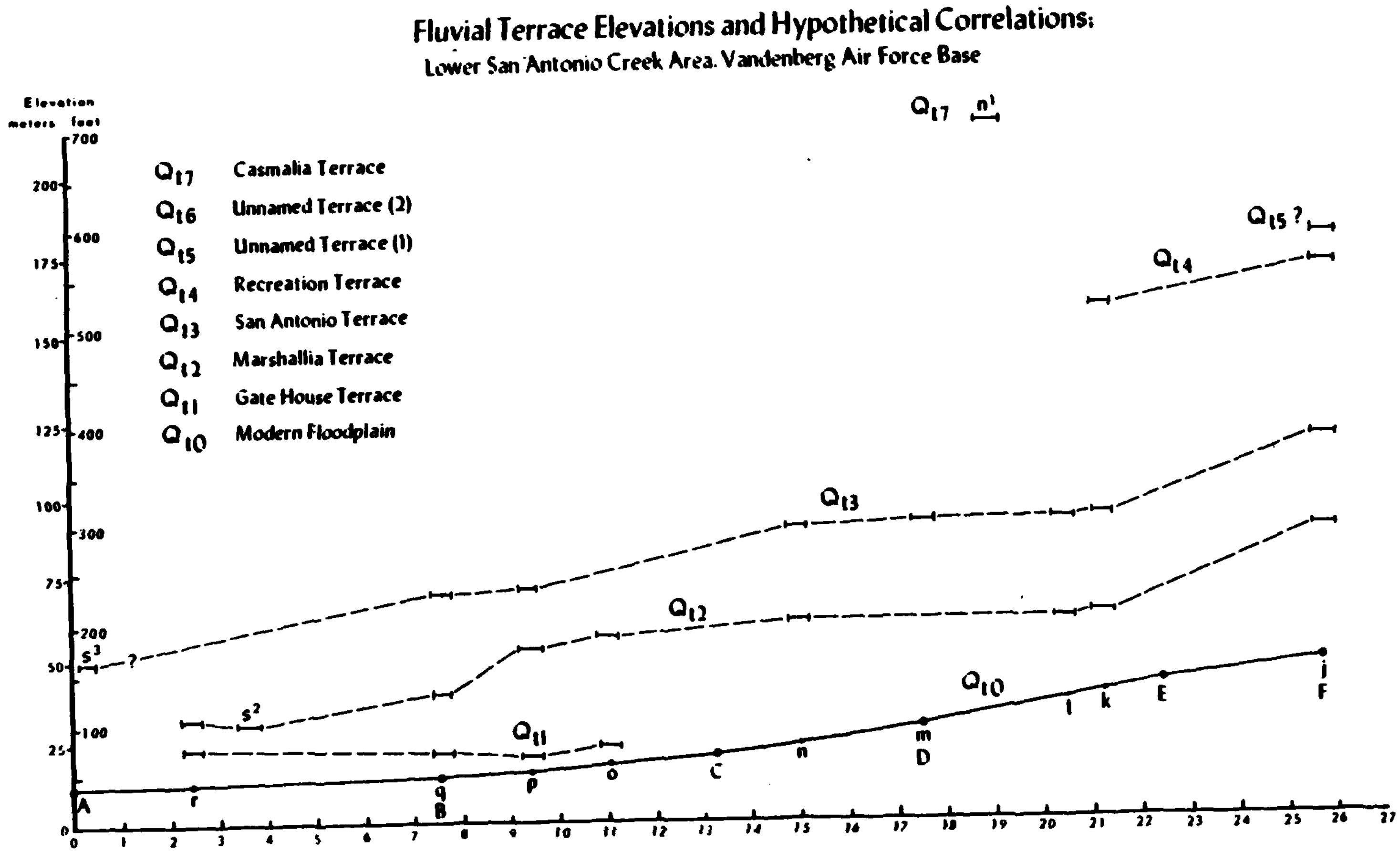


Figure 4-7. Fluvial Terrace Remnants Plotted by Elevation and Scaled Distance Along San Antonio Creek. The large letters (A, B, C, D, E, F) are end points for five straight line segments used to determine the gradient segments of San Antonio Creek. Lower case letters mark points where surface profiles intersect the modern stream gradient. See text for further discussion.

One of the oldest fluvial terraces in the region is the Qt_7 terrace that is exposed at the Caprock locality on the Lompoc-Casmalia Road, just south of Bishop Road where it directly overlies a marine terrace (*Figure 4-5*). Here marine bevelled Sisquoc bedrock is overlain by marine sands and gravels. This unit was uplifted and subaerially exposed, allowing the development of a strong soil (which represents an indefinite but considerable span of pedogenic time). A presumed fluvial sand unit (with a few gravels) was subsequently deposited on top of the soil. A soil also developed through this second unit, but its minimal development indicates that only a relatively short period of time was involved. This weakly developed soil was in turn buried by still another sandy unit of variable thickness, also presumably of fluvial origin. This fluvial unit, probably the Orcutt sand of Woodring and others (1943, Woodring and Bramlette 1950), occurs at one of the highest points of the landscape in the North Vandenberg area. The uppermost part of the sand unit is believed to have been reworked by wind into dunes.

Aside from modern alluvium, mapped Qt_0, the youngest alluvial terrace is the Qt_1 surface preserved in only several places in the lower reaches of San Antonio Creek. It is a remnant depositional terrace, provisionally judged to be very late Holocene in age. Possibly it may reflect a period when the mouth of San Antonio Creek was blocked by dunes, causing water backup and sediment aggradation. Breach of such a sand dam would promote stream incision of the higher than normal floodplain sediments, eventually leaving the terrace remnants.

In terms of archaeology, the most important stream terraces are the Qt_2 and the Qt_3 terraces. After development of these terraces in the late Pleistocene, dune sand at least twice blew across and buried them, probably during Holocene time (reasons given later). The surface is thus polygenetic, consisting of fluvial benches overlain by fluvial deposits that are buried by two sets of dune deposits. Historically, this complex has been referred to in the singular as the San Antonio Terrace, but in this paper the term is used only for the Qt_3 terrace. The lower, older dune unit has been exhumed in deflation depressions of the upper, younger dune unit. These exhumation depressions, called "windows" by those of us involved with the Vandenberg MX missile archaeological project, are very conspicuous in the field, on topographic maps (5 feet contour intervals), and on aerial photographs. In order to gain some idea of the general slope and relative relief of the lower, older dune surfaces cross-sectional profiles of seven windows were drawn and plotted against a constant elevation datum (200 feet: Figure 4-8a and 4-8b). The locations of windows and the profiles are shown on Figure 4-9, along with other data that will be referred to later in this report. The surface profiles show that the general slope of the long axes of the windows is northwest-southeast. It is inferred, nevertheless, that the general slope of the lower, older dune surface exposed in the windows probably matches that of the Qt_3 terrace surface that it buries. The latter surface should slope generally east-west, as does the San Antonio Creek floodplain, its modern analog. The local relief on the windowed surface probably reflects in part

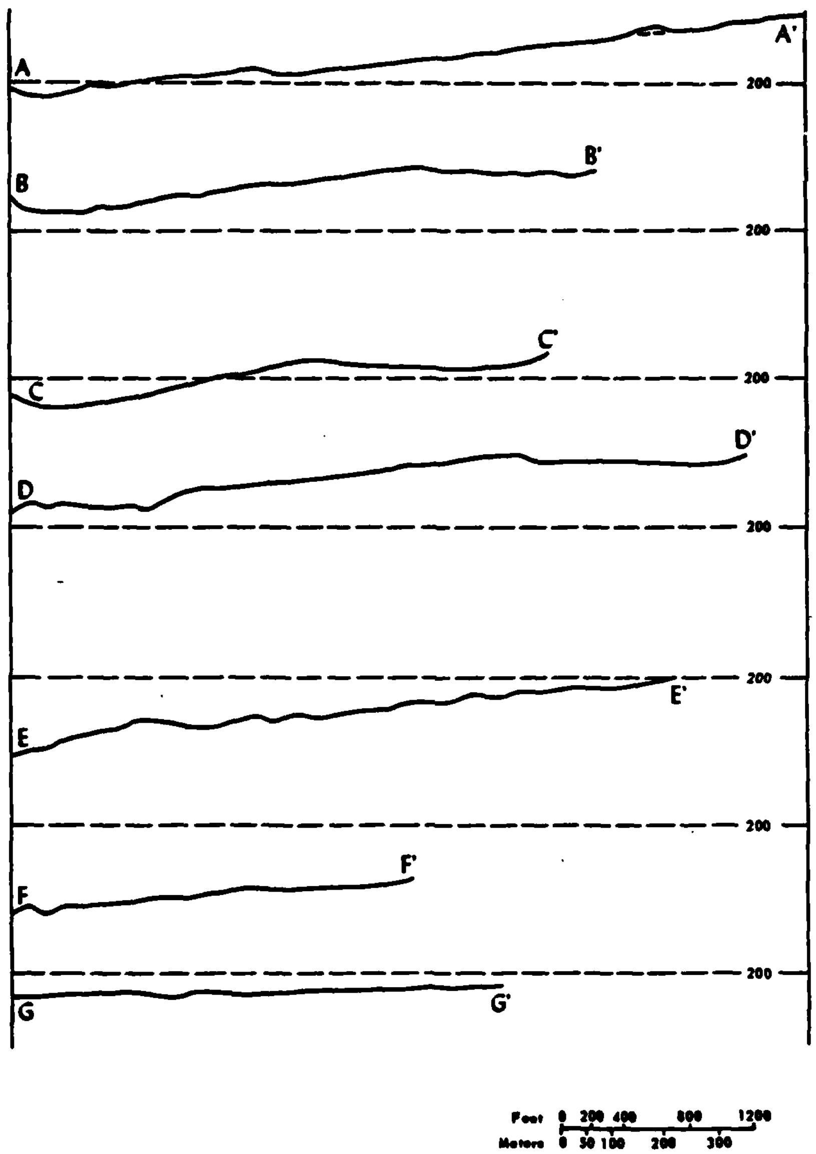


Figure 4-8a. Surface Profiles Drawn Across Seven San Antonio Terrace "Windows" on Five Foot Interval Contour Maps. These Profiles were then Plotted Against the 200 Foot Contour Elevation to Show the Variability of the Dune-Capped Qt_3 Surface Which is Exposed in the Windows (see Figure 4-9 for Locations.)

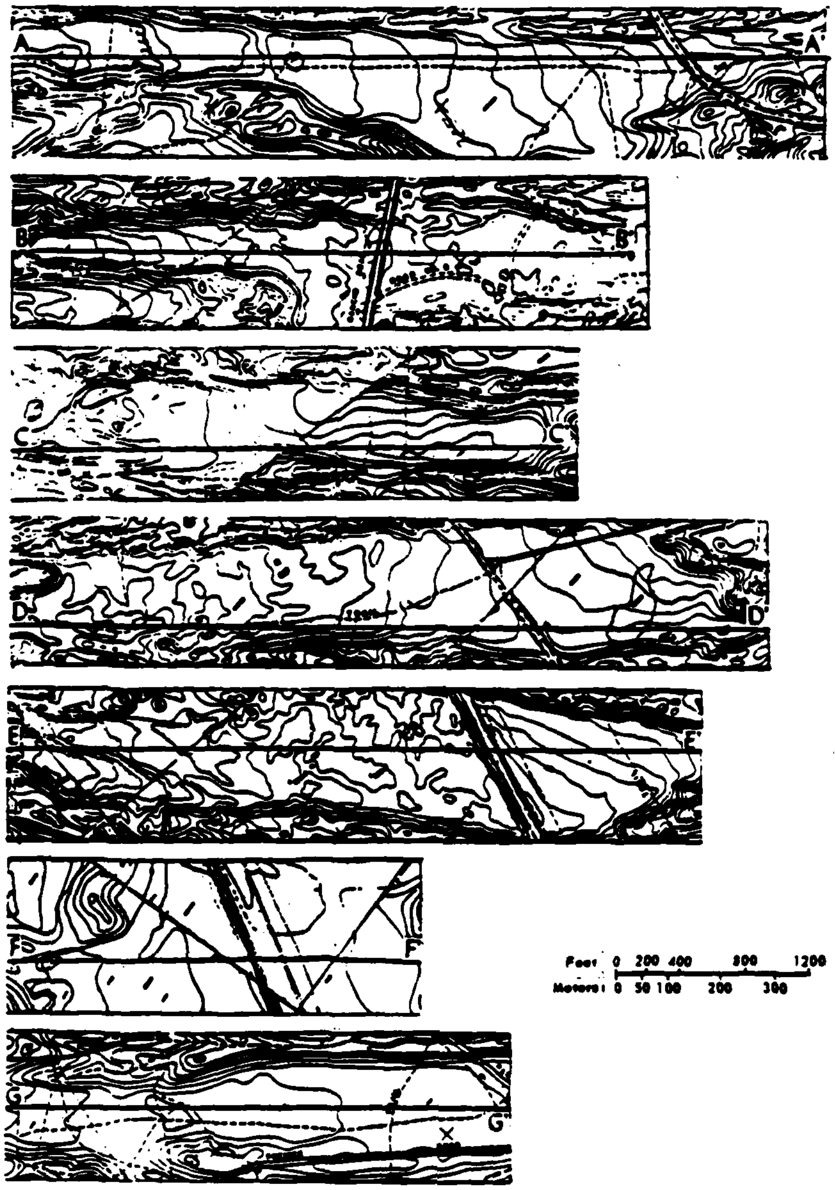


Figure 4-8b. Seven Topographic Map Segments on Which the Profiles of Figure 4-8a were Drawn. (See Figures 4-9 for Locations.)

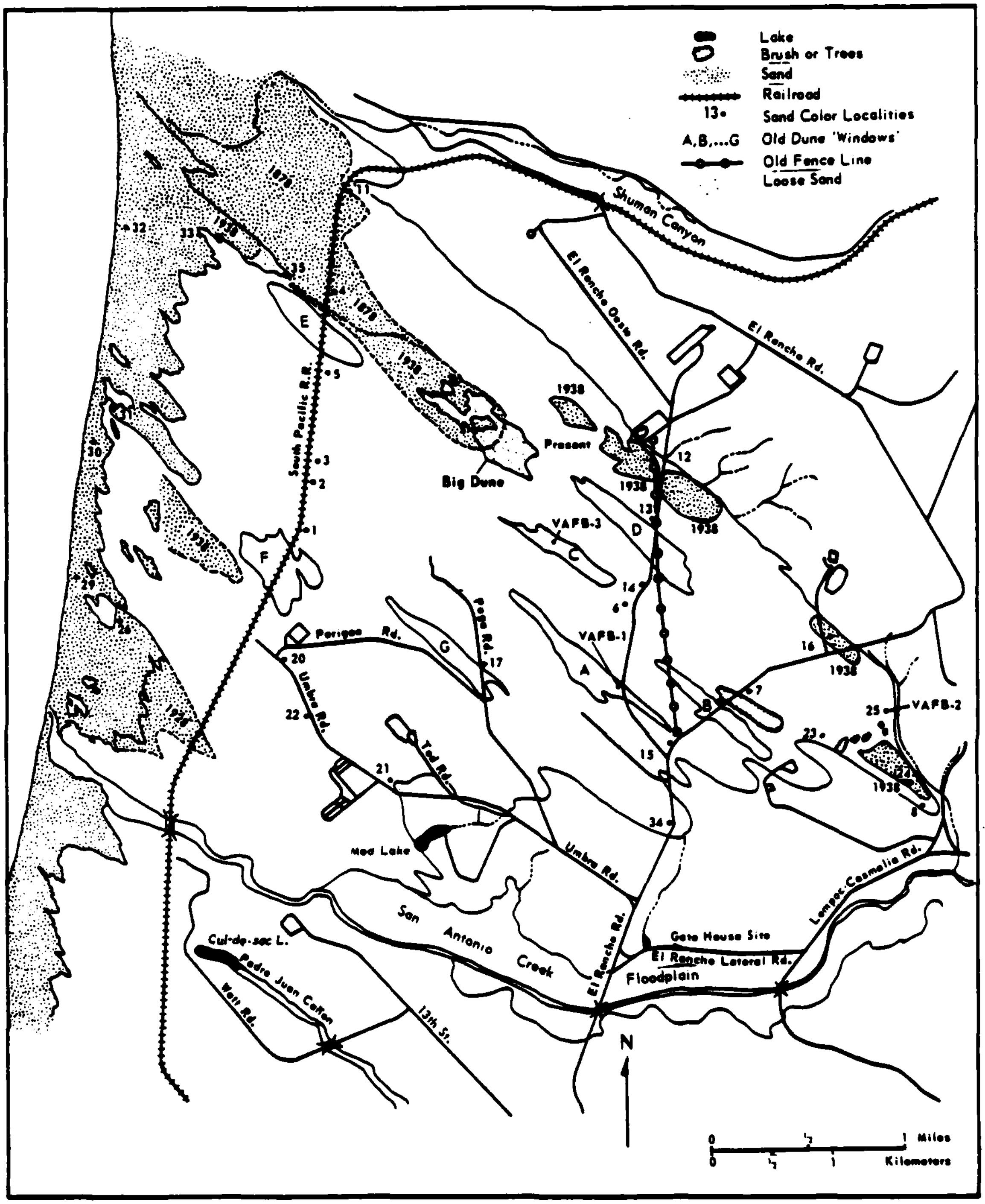


Figure 4-9. Location Map Showing Seven Profiled Qt_3 "Windows" (Figure 4-8), Roads, Lakes, a Fenceline, and Other Features Discussed in the Report. The Windows are Indicated by Upper Case Letters (A, B, C,...) that are Keyed to Figure 4-8.

the expected hummocky-ness of any dune covered surface, but to some extent probably also reflects the effects of deflation scour associated with the younger dune formation. In addition, residual dune patches of the younger, upper dunes may be present in the windows owing to incomplete eolian deflation of these dunes from the windows.

Alluvial Fans and Aprons

Alluvial fans occur in many places on Vandenberg. Most are small recent fans, but two are large and contribute importantly to the overall geomorphology and soils of the base (they are as much alluvial aprons as fans). One occurs in the Shuman Canyon area, and is deeply dissected by the canyon. Its surface is mapped as Qt_4 in Figure 4-3. The headward portions of this ancient fan abuts against the Casmalia Hills on the north side of Shuman Canyon. It is hypothesized that the fan predates Shuman Canyon and formerly extended across the canyon to North Mesa (hardly a mesa, but called such in the 1923 map of Marshallia Ranch; see Appendix II). Two surface profiles (H-H', I-I', on Figure 4-3) drawn from the dissected fan to North Mesa are shown in Figure 4-10; they support the hypothesis. Soils that developed on this ancient apron formed silica-cemented hardpans which appear to have aggraded upward through time concommitant with alluvial-colluvial accretion. The formation of this erosionally resistant durapan complex insured the preservation of the ancient colluvial aprons.

The other alluvial fan of soil geomorphic importance is the complex apron that spreads out from western Purisima Ridge onto the lower-lying Burton Mesa. The fans have buried the latter under many meters of sediment. Gulleys cut into the apron expose a history of eolian sedimentation followed by fan sedimentation, followed by more eolian and fan sedimentation, and so on. Exposures that reveal such histories are observed in upper Santa Lucia Canyon and in gulleys flanking the south side of Purisima Ridge, east of Vandenberg Road (S-20).

Sand Dunes

The sand dunes in the Vandenberg area have been described by Cooper (1967), briefly by Dibblee (1950), Woodring (1943), Woodring and Bramlette (1950), Woodring and others (1943), and by Brown in Chapter 5 of this report. North of Vandenberg, studies relating to coastal dunes have been executed by Brady (1978) in Morro Bay, and Envicom Corporation (1980a, 1980b) and Smith and others (1976) for the Nipomo area, which includes the Mussel Rock and Guadelupe dunes. On the northern Channel Islands dunes have been studied by Johnson (1972).

Origins: The Vandenberg-Santa Maria area is the site of the most extensive late Quaternary dune systems on the west coast of North America. There are several reasons for this. Both areas mark major breaks in the otherwise hilly or mountainous topography along this section of the north-south trending Coast of California. The marine layer of air within which the northwest prevailing winds at Vandenberg occur is frequently constrained

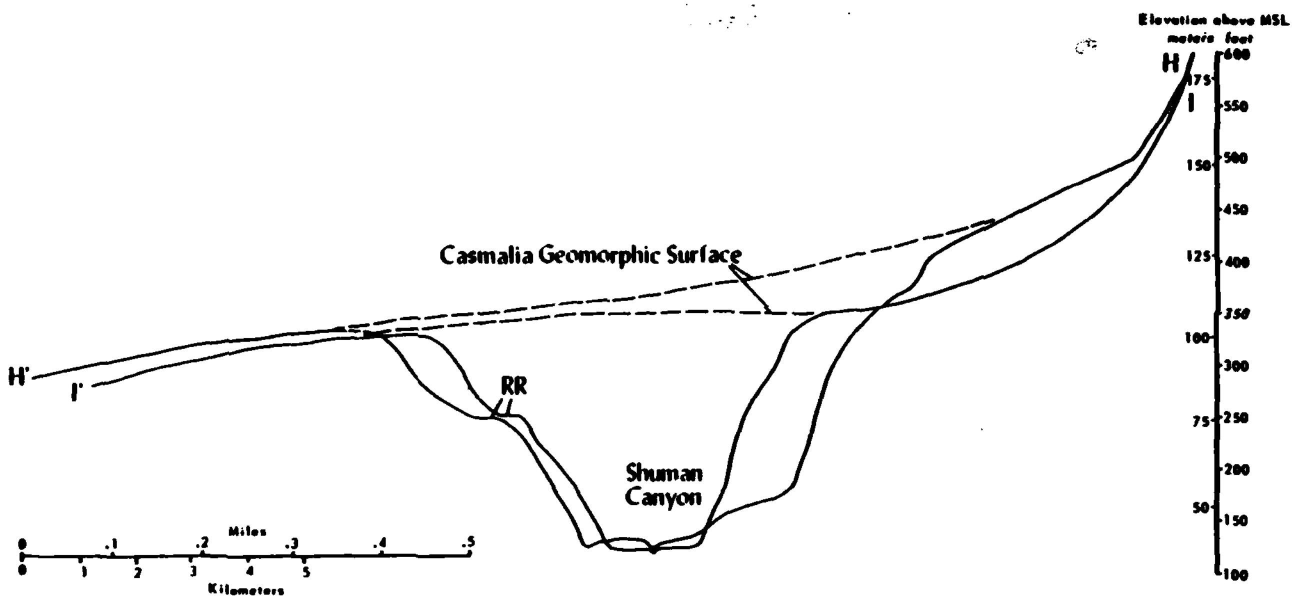


Figure 4-10. Two Surface Profiles Drawn Across Shuman Canyon from the Base of Casmalia Hills. The Profiles Suggest that the Casmalia Geomorphic Surface was an Existing Geomorphic Entity Prior to the Entrenchment of Shuman Canyon. Locations of the Surface Profiles are on Figure 4-3.

aloft by an inversion layer produced by downward descending upper air associated with the semipermanent north Pacific subtropical high pressure system. The latter reflects latitudinal linkage with Hadley circulation (Johnson 1977). Since the inversion layer is often lower in elevation than the topographic barrier of the California Coast Range mountains, the prevailing coastwise north-northwest winds are constrained by the mountains to flow south, parallel to the coast, though the air pressure gradient decreases to the east toward interior deserts. Where the coastwise mountain barriers are absent, as in the Santa Maria-Vandenberg areas, the prevailing wind-flow is onshore. The Santa Maria-Vandenberg lowlands, though slowly evolving and changing through geologic time, have been present for at least several hundreds of thousands of years, so that the prevailing coastwise winds have been afforded ample time to accumulate and move dunes.

That the prevailing wind direction at Vandenberg is from the northwest quadrant (WNW, NW, NNW) is shown by 10 years aggregated monthly wind direction data collected by the Vandenberg Air Weather Service (see Chapter 5). These data show that for winds with velocities greater than 10 knots (11.5 miles per hour; 18.5 km/hr), 72 percent blow from the northwest quadrant.

Marine coastal sand in the Vandenberg area is derived principally from sediment-laden Coast Range streams flowing to the sea along the central California coast, and from entrainment of sediments derived from sea cliff erosion. The California Current flows south along the coast and the associated longshore drift moves sand into the Santa Maria-Vandenberg areas. The absence of submarine canyons along this part of the coast prevents bypassing of longshore sediment down these canyons into offshore deeps, such as occurs elsewhere along the coast. The continental shelf is also very wide along this portion of the coast, which would have exposed to the wind a relatively broad shelf during glacially-induced low sea levels of the Pleistocene. For these collective reasons, under normal conditions more sand is thus made available for littoral constructional processes and, ultimately, for eolian sedimentation along this stretch of the coast than elsewhere. As noted in Chapter 5, however, dams built in historic time on rivers to the north of Vandenberg have reduced the amount of sand normally supplied to the coast, so that dune formation, which depends in part on such supplies, may now be retarded.

Dune Types: In Chapter 5, Brown has articulated the character of the younger dunes that occur on the San Antonio terrace; his discussion is as follows:

> The bulk of the sand within about 3/4 km of the coast has been blown into transverse ridges, a characteristic of areas with "unlimited" sand supply, "unlimited" area and steady winds (Melton 1940). Transverse dunes are oriented at 90 degree angles to the wind and resemble ocean waves in their surface morphology.

Vegetation-capped coppice dunes also occur in the coastal zone, normally within about 1/4 km of the strand.

Parabolic dunes also occur in the San Antonio dune field. For example, as seen on aerial photographs and maps the central dunes are distributed northwest-southeast across the landscape in long coalescing parabolic ridges open to windward. These are the "elongate parabolic" dunes discussed by Melton (1940) that are characteristic of areas with "strong winds of constant direction and impeding vegetation."

Brown's description is fitting for the youngest unstabilized (Modern) nearshore dunes and the older, farther inland Intermediate dunes that are recently stabilized or active only in a few places.

Dune Distributions: The Holocene dunes on Vandenberg, such as the Intermediate dunes on San Antonio terrace, are strikingly apparent on airphotos and maps, but the Pleistocene dunes, as indicated, are usually more subtle and difficult to discern. Sand of eolian origin, at least in part, occurs over much of Vandenberg Air Force Base. According to Dibblee (1950), dune sand makes up the upper part of the mostly non-marine mid to late Pleistocene Orcutt Formation; according to Woodring and Bramlette (1950: 51, 54) the Orcutt is a fluvial terrace deposit whose upper portion may be wind-winnowed. The Orcutt sand occurs widely over the north flanks of the Casmalia Hills near Orcutt and extensively throughout the south side of the Santa Maria Valley from the coast near Mussel Rock to the village of Sisquoc, some 34 km (21 miles) downwind to the east (Woodring 1943; Woodring, et al. 1943; Woodring and Bramlett 1950). It also variously occurs on the northwest flank of Point Sal Ridge, extending essentially to its summit (at Brown Road where it exhibits strong pedogenetic development); in the Caprock mesa district where Lompoc-Casmalia Road intersects Bishop Road, on South Vandenberg from Santa Ynez River to the ridge along the north edge of Honda Canyon, on the summit and flanks of the western Purisima Hills, and from near the coast east over all of Burton Mesa eastward into Santa Rita Valley beyond Purisima Mission. In the latter area the Orcutt sand is up to 46 m (150 feet) thick (Dibblee 1950:50), though probably only the very upper portion is of dune origin, the remainder being fluvial.

Dune Ages: In terms of ages Woodring and Bramlette (1950:54) classified all dune sands in the area as recent (Holocene), and grouped them into "...old, intermediate, and modern." Work done for this report revealed at least two dune sets that are older than Woodring and Bramlette's Old category; to maintain consistency of terminology they are referred to as Older and Ancient dunes. The Modern group includes all nearshore, whitish colored active dunes, such as the coastal Guadalupe dunes, and those between the coast and the Southern Pacific Railroad tracks on Vandenberg Air Force Base.

The "Intermediate" dunes are brownish in color and include those such as the sparsely vegetated and recently stabilized dunes immediately downwind (east of) the modern Guadalupe dunes, and those that cover much of the San Antonio Terrace between the Southern Pacific Railroad tracks and Marshallia Ranch headquarters. Woodring and Bramlette (1950:54) believe that the Intermediate dunes "...are probably not much older than the modern dunes, and differentiation between these two sets is locally indefinite." This writer agrees, and believes the Intermediate dunes are late Holocene in age, probably less than 2,000 years old. This conclusion is based on several lines of evidence.

First, the Intermediate age dunes in most places show little or no soil development. Secondly, the dunefield surface is characterized by "fresh" dunal morphology that appears little modified by mass wasting or other denudational processes. Third, Brown's studies (see Chapter 5) suggest that the dunes advance at rates of 0.42 km per century; the entire dune field could have thus migrated across the San Antonio terrace in the last 2,000 years. Fourth, lack of any appreciable organic bottom sediments in MOD Lake (Batchelder 1982) suggests that Intermediate dune advances which created the lake probably occurred no more than several hundred years ago (see also Chapter 5). Finally, two radiocarbon dates from the dunes, though problematic, are both younger than 2,000 years B.P. (Two dates from a 1 mm thick band of charcoal about 3 m below the Intermediate dune surface at the Missile Assembly Building foundation excavation gave discordant ages of more than 300 radiocarbon years before present [RYBP] [UCLA-2500H] and 1940 ± 240 RYBP [UCLA-25001]; obviously one of the dates is in error, and in light of evidence presented above which indicates youthfulness of the dunes, the younger date is probably the correct one.)

The "fresh" dunal morphology of the Intermediate dunes suggests that they were active in the very recent past. This inference is supported by an 1878 topographic map of part of the dunefield which shows a much greater area of unstabilized sand than at present (Figure 4-9). Tree ring analyses revealed that the oldest tree growing on the Intermediate dune field was a live oak (Quercus agrifolia) in the order of 100 years old (see Appendix A of this chapter for discussion of tree ring coring program). It is worth noting that sheep are known to be notorious agents of landscape disturbance via overgrazing (Johnson 1980), and Jesus Maria Ranch had many sheep on it in the last half of the 19th century, 10,000 at one point (see Appendix II). Airphotos taken during 1928 and 1938 show a marked decrease in areas of active dune sand during that 10 year period (Figure 4-9). On the 1928 airphotos, the area west of the old fence line (Figure 4-9) is seen to be much sparser in ground cover than east of it, which clearly was owed to stock grazing. In fact, were it not for repeated efforts of dune stabilization during this century by the Southern Pacific Railway Company and the U.S. Military (see Chapter 5 and Appendix II), probably much more free sand in the Intermediate dunefield would exist today (only Big Dune on Figure 4-9 is active today).

During foundation excavations for the MX Missile Assembly Building a weak organic soil that marked the buried Oceano surface was exposed some 11.7 m (38.5 feet) below the Intermediate dune surface. The soil is the buried equivalent of the adjacent VAFB-1 window (Sk) soil described in a later section. Bulk material was collected from it for a mean residency time (mrt) radiocarbon date on the soil organic matter (to be dated in 1984-1985 at the Illinois State Geological Survey, Urbana). Though not available at this writing, the date will shed additional light on the age of the Intermediate dune sand and when it buried the preexisting Oceano surface (i.e., the date should be older than Intermediate dunes).

The Old dunes occur widely throughout the brush and grass areas of the southern Santa Maria River Valley, from Mussel Point to Sisquoc. The main Marshallia Ranch headquarters is built upon Old dune terrain, and this surface extends under the Intermediate dunes towards the ocean to the west where it is exhumed in the blowout "windows" noted earlier. Because the Modern and Intermediate dunes respectively are of the transverse and parabolic types, it is presumed that the Old dunes also were of these types, though their original form has been subsequently blurred through rainbeat mass wasting processes and by earlier historic landuse and cultivation (see Appendix II; 1983 airphotos, Whittier College Library; U.S. Department of Agriculture, Soil Conservation Service 1972:59).

As mentioned, Woodring and Bramlette (1950:54) believe that the Old dunes were of geologically Recent age. Presumably their judgment was based on intuition, as no evidence or data were given to support it. Regardless, three lines of evidence (two direct, one indirect) suggest that the Old dunes date from early to mid-late Holocene time. Direct evidence is in the Oceano soils that are developed on the dunes. These soils are not well developed. Little clay has been translocated to the B horizon of the soils, and most Old dunes have A/C soil profiles. Three samples from A horizons of soils developed on the Old dunes were collected for mrt C-14 dates on organic carbon (to be dated in 1984-1985 at the Illinois State Geological Survey, Urbana). One, mentioned in the previous section, was from a buried Old dune profile about 213.5 feet (65.1 m) above mean sea level and approximately 38.5 feet (11.7 m) below the surface of the Intermediate dune at the MAB site. The two others were taken at 10.20 cm and 70 cm to 80 cm depths in a soil pit at VAFB-3 (Figure 4-9) at the crest of a window. These dates, when determined, should shed light on the age of the soils, and thus the age of the Old dunes (i.e., the dates should be younger than the dunes).

Another line of direct evidence comes from a new road exposure on Old dune terrain on the south side of the Santa Maria River near its mouth (400 m southwest of Union Oil Well No. 31-18, 200 m east of Union Oil Well 33-13). A large aboriginal shell midden 1.6 m thick is visible in the cut. The midden rests directly upon loose, unpedogeneticized Old dune sand that was apparently active when habitation of the site first occurred. Shells for

C-14 dating were collected at 150 cm to 160 cm depths (the contact) and again at 40 cm depth. The lowest date should indicate when the dunes were locally active, and the approximate time of initial human habitation at the site.

A third line of evidence for the inferred early to mid Holocene age of the Old dunes is indirect, and involves fossil pollen and climate data. A sediment core from the Santa Barbara Basin was analyzed for pollen by Heusser (1978). She concluded that a vegetation change from mesic to semi-arid (or wet semi-arid to dry semi-arid) took place very roughly 7,800 years ago. This marked the beginning of an approximately 5,000 year long mid Holocene warm-dry interval that has been referred to as the Xerothermic in California (Axelrod 1967). According the Heusser (1978), the warmer-drier period peaked about 5,700 years ago and ended roughly 2,300 years ago. The warm-dry period has been recently identified in pollen analyses of deep sediment cores from Clear Lake in the Coast Ranges of northern central California (Adam and West 1983; see also comments in Johnson 1977). Such warm-dry conditions should decrease vegetation cover and promote migration of coastal dunes inland.

The Older dunes also have subdued dunal morphology like Intermediate dunes, but unlike them they have more strongly developed soils (i.e., more reddish colors, and textural B horizons). Examples are those that occur across at least part of Burton Mesa and which are exposed as reddish brown pedogeneticized sands in upper Santa Lucia Canyon in the western Purisima Hills, and in the roadcuts of Washington Avenue where it intersects the western slopes of Pine Canyon. It is conceivable, if not probable, that the Older dunes consist of a complex of multiple dune units of different ages, or are at least re-worked portions of one or more dune units. If so, it would be almost impossible to sort them out chronostratigraphically because of the complexities that characterize such deposits, and because soils developed in them are now so similar in morphology that they cannot be confidently used for age-discrimination purposes. They are provisionally inferred to be late Pleistocene in age, and probably began forming some 125,000 years ago during oxygen isotope stage 5e when sea level was several meters higher than now, and when the climate and vegetation was respectively more arid and sparse than even in early to mid Holocene time (Johnson 1983).

A much older, fifth group of strongly pedogeneticized dunes occur on Vandenberg Air Force Base and these are designated the Ancient dunes. As used here, the term includes the wind re-worked upper portion of the Orcutt sand (Qt_7). The Ancient dunes are, as indicated earlier, preserved as relict remnants on the north flank of Point Sal Ridge extending to nearly its summit at 366 m (1200 feet) elevation (where Brown Road crosses the base boundary). Ancient dunes also occur on the highest parts of the Casmalia geomorphic surface where they are exposed at the summit of Bishop Road and the Lompoc-Casmalia Road (Figure 5, Plate 2a). They are presumed to be re-worked Orcutt sands, which here cover a subjacent marine platform. Relict patchy remnants of Ancient dunes also occur at the summit of the western end of Purisima Ridge above Vandenberg Road (Highway S-20), and

on Burton Mesa where it is exposed in road cuts, borrow pits and quarries. Finally, Ancient dunes occur variously on South Vandenberg where they blanket the Burton Mesa-equivalent marine platform and where they occur as re-worked upper Orcutt sand.

The age set of the Ancient dune is uncertain as no direct dating of it has been made to the writer's knowledge. It is provisionally assigned a pre-oxygen isotope state 5 age (i.e., greater than 125,000 B.P.). Probably the dunes formed during an earlier interglacial high stand of the sea than the last one, perhaps during Stages 7, 9 or 11. If so, they would be older than 200,000 years (Shackleton and Opdyke 1973). They are provisionally correlated with similar ancient dune deposits in Cambria, on the Northern Channel Islands, and in the San Diego area (Johnson 1972).

Woodring and Bramlette (1950:54) noted that the different age sets of dunes "...form in general parallel belts succeeding one another inland in order of increasing age." While this writer's observations support the generalization I would add that the oldest (Ancient) dunes, which they did not define, occupy the higher parts of the present landscape. They also believed that "...all the dune sand is considered recent..." (1950:54), which simply cannot be true.

Dune Color: The Vandenberg dunes generally are youngest and lightest in color near the coast, and are older and take on reddish hues and higher chromas with increasing distance inland. This appears to be true for the Modern, Intermediate, Old, Older, and Ancient age sets. Let us discuss and explain this pattern.

The increase in reddish hue of the sand with distance inland is believed to be owed to two principal factors: leaching of carbonates (i.e., removal of the whitest color) and dune reddening through time. The latter is itself principally owed to two factors: weathering of iron-bearing minerals with time, and reddening by soil microbial activity at or immediately above the water table (see Chapter 6). The process of dune reddening with time through iron-mineral weathering has been articulated by Norris (1969) and other workers. Basically, other things equal, the older the dunes the redder they get (up to a point, of course). This can be seen on Table 2 which shows sand colors determined at various places across the San Antonio dunefield (Intermediate dunes). The localities on Table 2 match those shown in Figure 4-9. Sand reddening imparted by weathering is evident in the Older dunes exposed near the head of Santa Lucia Canyon on Purisima Ridge, and where Washington Street drops below Burton Mesa in Pine Canyon.

Soil microbial activity promotes reddening by precipitating iron from soil and ground water at the piezometric surface. That this almost certainly occurs is evidenced in many of the interdune wetlands, especially those near the ocean (see Chapter 6, this report). Localities 31, 32c, 32d, 32e, and 36 on Table 2 are sites where reddish hues and high chromas of sands are being generated by aerobic microbial action. Similar reddish colors are observed within the zone of fluctuating groundwater in the soil pit dug at VAFB-1 in Intermediate dune window A (Figures 4-8 and 4-9). Iron-cemented sand concretions form in the zone and these likewise give reddish hues and bright

Locality	Environment[1]	Color Notation	Wettable[2] Nonwettable	Loc.	Environment[1]	Color Notation	Wettable[2] Nonwettable
1	D	10YR 3.5/4m, 7.5YR 5/4d	NW	20	D	10YR 3/4m, 10YR 5/4d	NW
2	D	10YR 2/2m, 7.5 YR 3.5/4d	NW	21	D	10YR 3/4m, 7.5YR 5/4d	NW
3	D	7.5YR 4.5/6m, 10YR 6/6d	NW	22	D	7.5YR 3.5/4m, 7.5YR 5/4d	NW
5	D	10YR 4/4m, 10YR 6/5d	NW	23	D	7.5YR 3/4m, 7.5YR 4.5/5d	NW(S1)
6	D	7.5YR 4/4m, 7.5YR 5/4d	W	24	D	7.5YR a4/4m, 7.5YR 4.5/6d	W
7	D	7.5YR 3.5/6m, 7.5YR 5/6d	W	25	D	7.5YR 4/5m, 7.5YR 4/5d	VNW
8	D	7.5YR 3.5/4m, 7.5YR 4.5/4d.	W	26	D	7.5YR 4/4m, 7.5YR 6/5d	W
11	D	10YR 4/3m, 10YR 6/4d	NW	29	B	10YR 4.5/3m, 10YR 6.5/3d	W
12	D	7.5YR 4/4m, 7.5YR 6/6d	W	30	D	7.5YR a4/3m, 10YR 6.5/3d	W
13	D	7.5YR 4/4m, 7.5YR 6/6d	NW	31	P	5YR 4/8m, 5YR 4/8d	-
14	D	7.5YR 4/4m, 7.5YR 6/6d	NW	32a	D	10YR 5/3m, 10YR 7/2d	NW(S1)
15	D	7.5YR 4/4m, 7.5YR 5/4d	NW	32b	B	10YR 5/3m, 10YR 7/2d	NW(VS1)
16	D	7.5YR 4/5m, 7.5YR 5/5d	W	32c	P	5YR 4/6m, 5YR 4.5/6	-
17	D	7.5YR 4/4m, 7.5YR 5/5d	NW	32d	PC	2.5YR 2.5/5m, 5YR 4/6d	-
18	D	7.5YR 4/4m, 7.5YR 5/6d	NW(VS1)	32e	PC	2.5YR 2.5/4m, 5YR 4/7d	-
				33	D	10YR 4.5/3m, 10YR 6/2.5d	W
				34	D	7.5YR 4/4m, 7.5YR 5/4d	NW(S1)
				35	D	10YR 5/4m	W
				36	P	2.5YR 4/4m, 2.5 5/4d	

[1]Abbreviation Key: D=dune; B=beach; P=pond; PC=pond concretion (iron cemented).

[2]Abbreviation Key: W=wettable; NW=non-wettable; Sl=slightly; Vsl=very slightly; (a non-wettable soil is one where water, when eye-droppered onto it, "beads up" into a sphere and only slowly wets the sediment; the condition is presumably promoted by surface fires).

Table 4-2. Munsell Colors of Dune and Beach Sand, San Antonio Terrace Area, Vandenberg Air Force Base, California.

chromas (2.5YR 2.5/5 moist colors). Apparently organic matter (carbon) in the wet depressions and in the soils is used as energy by microbes in the precipitation of iron. The thus reddened soil is then deflated away and contributes a red color to the downwind dunes. This microbal-related iron precipitation process is also believed to prompt reddish plinthite formation in the dunes (iron-cemented sand concretions). These processes may be seen occurring in many places in the San Antonio dune field.

Mound Microrelief ("Mima Mounds")

Mound-microrelief occurs in several places on Vandenberg Air Force Base. The mounds are several meters in diameter and a meter or so high. They are best expressed in several grassy depressions that occur on the south side of the base airstrip along either side of Tangair Road. A depression with numerous mounds occurs on the north end of Nitro Loop Road, immediately south of where Avo Road intersects Tangair Road. Other nearby depressional mounds may be seen on airphotos. A second occurrence of "mima mounds" is on the flattish parts of the Casmalia geomorphic surface on the north side of Shuman Canyon.

For what it is worth, it is noted that many rodent burrows were present on the mounds and to a lesser extend in the dry intermound lowlands when the grassy depressions were visited in July 1982. The presence of dried "water moss" in these lowlands indicates that they contain standing water during wet periods. The rodent burrows in the intermound lowlands appeared very fresh, as though the animals had only recently occupied them. Indeed, it would appear as though almost the entire rodent population of the depressions would of necessity be forced to occupy the mounds for those periods of time during which the lowlands are flooded, probably during most winters. They would re-colonize the lowlands in the spring and early summer, after the ponds dry and new grass sprouts.

A number of large rounded boulders and cobbles were noted in the intermound areas of the Avo Road depression. Probably they are marine gravels related to the underlying marine platform, indicating a very thin veneer of terrace cover here.

On the 1938 Fairchild airphotos (on file at Whittier College, Whittier, California) numerous round mound-like features are visible on Burton Mesa about 0.5 km southwest of the Avo Road depression, at other nearby areas on the mesa, and on the Casmalia geomorphic surface southwest of El Rancho Oeste Road. They were noted on the photos after field work ended, and thus were not visited. Presumably they are either mound microrelief features (coppice mound?) or regularly spaced clumps of scrub vegetation.

The origins of the depression mounds of Burton Mesa and the microrelief in the Shuman Canyon area are unclear. Both areas are grassed (at least at present) and have subsoil hardpans (durapans). Subsoil hardpans are not uncommon on mound microrelief terrain elsewhere in California (e.g., Linda Vista terrace of San Diego; Great Valley area). Whether rodents have played

a role in their formation is not certain, but the great number of new and old borrows noted on the depression mounds suggests a possible genetic linkage. Speculations on the origin of mound microrelief elsewhere have generated a plethora of lively debates and red faces. Far more hypotheses for their origins have been advanced than there are words in this sentence (see Quinn 1976). The most accepted ones are the coppice mound, animal mound, and gilgai (shrinking-swelling claypans) hypotheses. Further work is required to clarify the origins of the Vandenberg mounds.

The origins of the depressions which occur on Burton Mesa, and in which the best developed mound microrelief occurs, is also unclear. Several of the depressions are circular or oblong in shape, but at least one (along the north edge of Tangair Road) is squarish, suggesting in this case a human origin. Possibly they represent localized eolian blowouts, or as seems less likely, are areas that for some inexplicable reason escaped the eolian sedimentation that otherwise occurred across Burton Mesa. It is also possible that they are Pleistocene "dusting wallows" of large, now extinct mammals (elephants, camels, etc.), and thereby analogous in inferred origin to some of the depressions on the High Plains of the United States.

The depressions are evident on the 1928 air photos, and thus predate them. As noted above, the squarish shape of at least one of the depressions hints at a possible anthropic origin, but this possibility is not supported by any other evidence noted by this writer.

SOILS

The soils in the Vandenberg area range from those exhibiting extreme youthfulness in development, as on the Modern coastal dunes (raw sand) on the San Antonio terrace, to those exhibiting extreme development, as on the Ancient dunes of the Orcutt sand on the Casmalia terrace. In this section of the report, the type and nature of the soils of Vandenberg are reviewed, beginning with the youngest dunes and ending with the oldest. This information is based on field work by myself and by project archaeologists, and on information taken from Soil Survey of Northern Santa Barbara Area, California (U.S. Department of Agriculture Soil Conservation Service 1972). For simplicity of citation the latter is hereafter referred to as the Soil Survey.

Modern Dune Soils

As mentioned, the soils developed on the active Modern coastal dunes are extremely young, and in fact the parent material has not stabliized. Thus, they are soils only in a technical sense. The sand is whitish in color, and slightly calcareous, the carbonates (and the whitish color to some extent) being derived from comminuted marine shells. They are mapped as DUE, dune land, in the Soil Survey.

Intermediate Dune Soils

These soils occur on the recently stabilized Intermediate dunes that occur on the San Antonio terrace. They are also mapped as DUE, dune land. These soils show minimal development in most instances, but are still better developed than the Modern dune soils except where they are active or have been historically active (Figure 4-9). They have a reddish yellow to brownish color (Table 2). Soil profiles on these sands range from those with essentially no development, to some with weak A/C profiles that have slightly (organic matter) darkened A horizons, to (rarely) those showing moderate development with thin, dark (A_1) horizons, thin bleached eluvial (A_2) horizons, and with thin iron-cemented B horizons. The latter profile was seen only at one place (VAFB-2) on the Intermediate dunes (Figure 4-9). Laboratory and chemical data on the profile at VAFB-2 are given in Tables 4-3 and 4-4, Figures 4-11, 4-12a, and 4-12b, Plate 3.

The differences in strength of profile development on the Intermediate dunes apparently reflects the length of time a particular portion of the dune field has remained stable. For example, the stability of the local dune area of VAFB-2 must have been longer than where slightly darkened (younger) A/C profiles occur. Dunes which show no soil horizonation or near-surface darkening probably were active historically or proto-historically.

Old Dune Soils

As mentioned earlier in this report, the Old dunes migrated over late Pleistocene terrace deposits in the lower San Antonio Creek area. Their greatest extent on north Vandenberg is southeast of the line of eucalyptus trees on Marshallia Ranch, which marks the boundary between them and the younger Intermediate age set of dunes. They also blanket the Qt_2 and Qt_3 terraces on the north side of San Antonio Creek east of the Lompoc Casmalia Road, possibly extending intermittently as far east as Barka Slough (Figure 4-3). They are also very extensive on the south side of Santa Maria Valley. The soils developed on these dunes are mapped according to shape and degree of erosion as Oceano sand (OcA, 0-2 percent; OcD, 2-15 percent; OcD_3, 2-15 percent severely eroded).

Oceano Sand: The Oceano series is classified as a mixed, thermic, Alfic Xeropsamment (Soil Survey p. 169). The following typical series description is based on a representative profile a few miles southeast of Santa Maria, is given in Appendix A, and is from page 59 of Soil Survey.

> The Oceano series consists of excessively drained sandy soils that formed in old coastal sand dunes. These soils are on coastal plains in scattered areas, between the Santa Maria River and Point Arguello and within 20 miles of the coast. Slopes range from 0 to 15 percent. The vegetation is sparse annual grasses, forbs, and sagebrush. Elevations range from about sea level to 800 feet. The average annual rainfall is 14 to 20 inches, the average annual air temperature is about 57 degrees F., and the frost-free season is about 300 to 320 days. Oceano soils are associated with Marina soils.

In respresentative profile, the surface layer is grayish brown and light brownish-gray sand about 20 inches thick. It is underlain by pale-brown and light yellowish-brown sand extending to a depth of more than 60 inches. The sand is mostly feldspathic and quartzitic; the grains are fine and medium in size and are rounded. A few clay or iron bands are below the surface layer and extend to undetermined depths.

Oceano soils are used for irrigated crops and for range.

Table 4-3. Marshallia Dump Site, VAFB-2: Physical Properties.

	Percent			
Depth (cm)	sand(2-0.05 mm)	silt (50-2)	clay (2)	Horizons
0-5	97.7	-	4.4	A_1
5-15	98.4	-	1.7	A_2
15-24	98.9	-	2.7	B_{ir}
24-34	98.6	-	4.3	
57-67	98.9	-	1.4	Cox
67-77	99.0	-	0.9	C_{g1}
90-100	99.1	-	2.2	C_{g2}
112-122	98.9	-		C_{g3}
162-173	99.0	-		C_{g4}

cm	ppm		%	Meq/100 gm	%	ppm/percent				mmhos/cm	
Depth	P_1	pH	OM	CEC	BS	Potassium	Magnesium	Calcium	Sodium	Sol. Salts	Horizons
0-5	23	5.7	5.0	6.1	79.0	54/2.3	65/8.9	800/65.6	31/2.2	0.1	A_1
5-15	29	5.3	2.1	4.5	69.0	47/8.3	45/8.3	500/55.3	28/2.7	0.1	A_2
15-24	23	5.3	2.3	2.5	69.0	44/4.5	30/10.0	250/49.9	27/4.71	0.1	B_{1r}
24-34	35	5.5	0.7	2.0	74.0	27/3.5	20/8.5	200/50.8	51/11.3	0.1	C_{ox}
57-67	33	4.8	0.2	2.1	53.0	19/2.3	15/5.9	150/35.4	46/9.4	0.1	
67-77	27	5.5	0.2	1.6	74.0	26/4.3	15/8.0	150/47.9	50/13.9	0.1	C_{g1}
90-100	26	5.7	0.1	1.3	79.0	29/5.6	15/9.3	150/56.0	25/8.1	0.1	C_{g2}
112-122	22	6.0	0.1	1.8	85.0	51/7.4	25/11.8	200/56.7	37/9.1	0.1	C_{g3}
162-172	23	6.2	0.1	1.8	88.0	63/9.0	30/13.9	200/55.5	40/9.7	0.1	C_{g4}

Table 4-4. Marshallia Dump Site, VAFB-2: Chemical Properties.

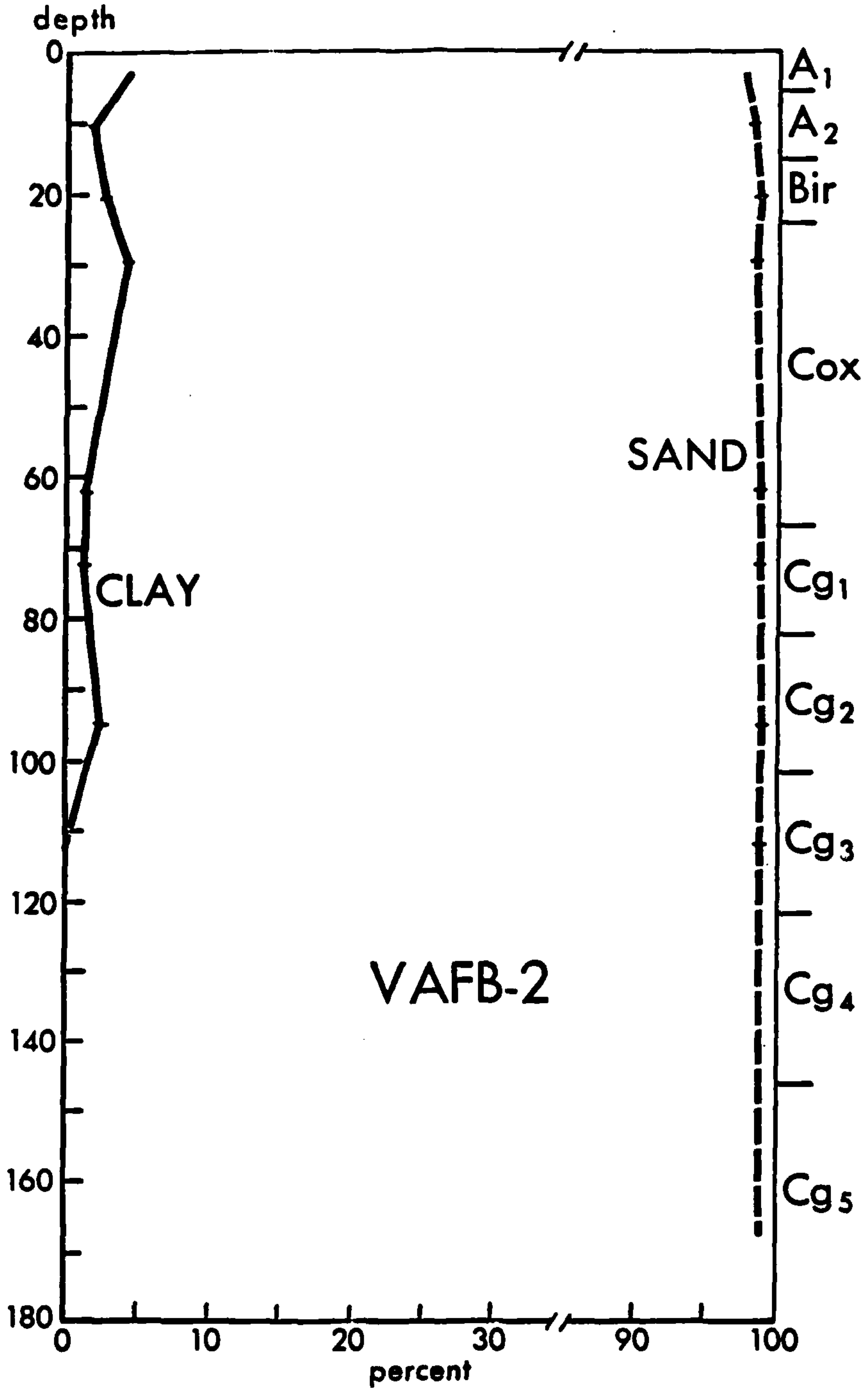


Figure 4-11. Particle Size Analyses of the Most Developed Pedon Observed in the Intermediate Dunes, Marshallia Dump Site, Vandenberg Air Force Base. (See Table 4-3.)

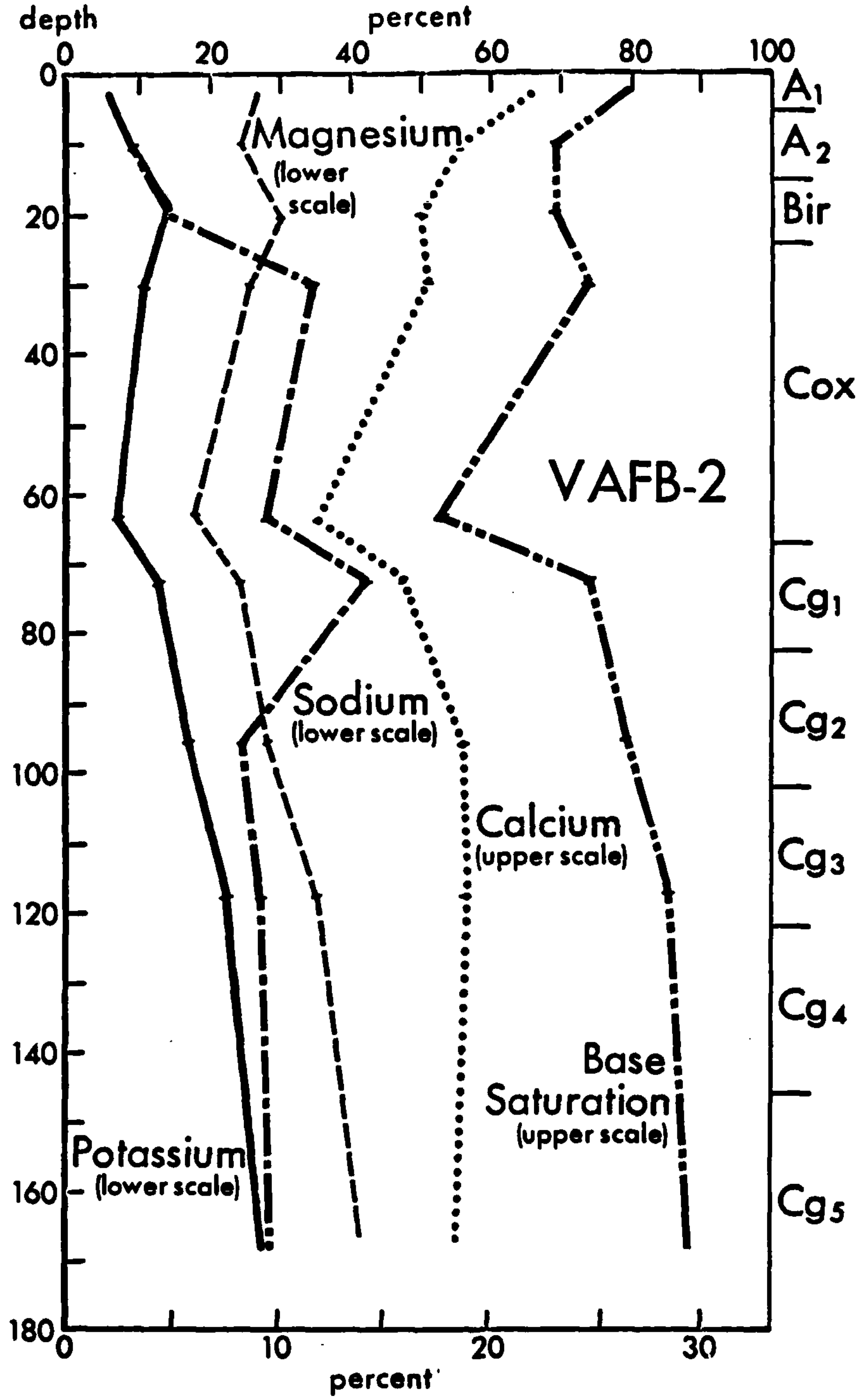


Figure 4-12a. Chemical Analyses of the Most Developed Pedon Observed in the Intermediate Dunes, Marshallia Dump Site, Vandenberg Air Force Base. (See Table 4-4.)

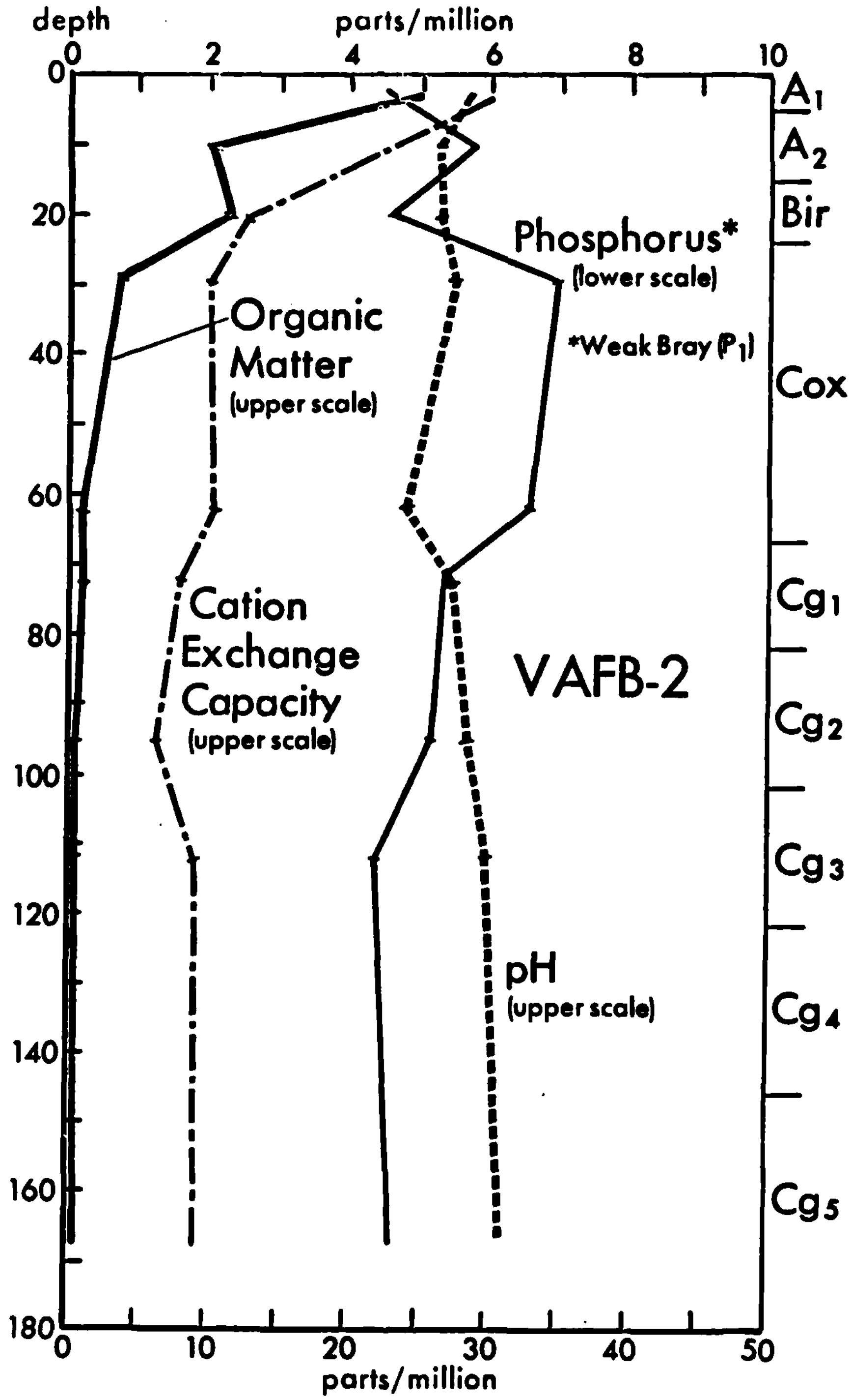
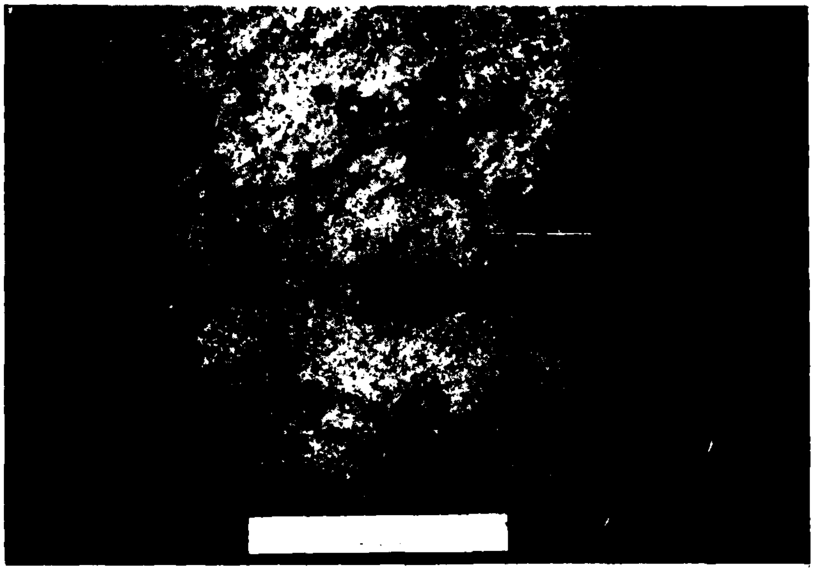


Figure 4-12b. Chemical Analyses of the Most Developed Pedon Observed in the Intermediate Dunes, Marshallia Dump Site, Vandenberg Air Force Base. (See Table 4-4.)



a

b

Plate 3. Photos of B_{ir} horizon, at VAFB-2, Intermediate dune soil, Marshallia Dump Site. Top photo (a) shows mega-structures and cracking of B_{ir} horizon (oblique photo looking at top of B horizon - A horizon removed). Lower photo (b) shows chunk of iron indurated mass from B_{ir} horizon.

Exhumed Oceano Surface (Window Soils): Intermediate dunes, as mentioned earlier, bury Old dunes on the San Antonio terrace west of Marshallia Ranch. Presumably, before the Intermediate dunes advanced over the Old dune-terrace complex in late Holocene time, the Oceano soils had, to some extent, already experienced some pedogenesis prior to burial. They then were probably well drained like the unburied Oceano. However, as mentioned earlier, exhumed Old dune surfaces are exposed in blowout depressions within the Intermediate age dunefield. Soils in these windows are now imperfectly, poorly, or very poorly drained. Though both the window and Oceano soils are developed on the same (Oceano) geomorphic surface, the former are less well developed owing to their being formerly buried and thus cut off from normal pedogenic processes during the period of burial. These windows are mapped on the Soil Survey as Sk (sandy alluvial land, wet) and described as follows (p. 70):

> Sandy alluvial land, wet (Sk), is made up of strata of coarse or moderately coarse materials recently deposited by wind and water. It commonly contains strata of peat in the profile. In some places the profile is mottled throughout. In all areas the substrata are mottled.
>
> This land type occurs in small areas scattered throughout large and small valleys and within areas of dune land. A water table is within 2 to 3 feet of the surface at least part of the year. A few areas are waterlogged within a foot of the surface throughout the year. In some areas, the vegetation consists of willows, alders, brush and water-tolerant grasses and forbs. In others, it is willows, marshgrass, sedges, and saltgrass.

The imperfectly to very poorly drained window (Sk) soils are interpreted as being deflationally modified formerly well drained soils, now characterized by a high water table brought about by late Holocene creation of high surrounding land via burial by Intermediate dunes. The later, younger dunes serve as porous traps for rainwater, and their emplacement probably has caused a rise in the local water table. The water table is now higher and fluctuates under the windows as noted in the above quote, and as observed by Brown (Chapter 5).

During field reconnaisances, it was noted that iron-cemented sand concretions occur sporadically on the surface of some of the windows, along with some presumably stream-rounded pebbles and an occasional wind-polished anthropic flake. Analyses of three archaeological pits (SBa-1170) and soil analysis of a soil pit (VAFB-1) dug into windows adjacent to the Missile Assembly Building showed that the iron-cemented sand concretions, the pebbles, and the artifacts extended from the surface to more than a meter into the Old dune soil (Tables 4-5 through 4-10, Figures 4-13 to 4-16b,

Plate 4). The artifacts from SBa-1170 were ranked by Douglas Bamforth (M. Glassow, personal communication January 1983) according to size and number, and the degree of wind polish (Table 4-11). All of the artifacts and pebbles, and most of the concretions, were small. The latter, interestingly, were mainly of small size and weight in the upper profile, and of larger size and greater weight in the lower profile (Tables 4-5 through 4-10). In fact, abundant relatively large and heavy concretions were first noted in the lower profile (B_{ir} horizon) of the window soil at VAFB-1 when the pit shown in Plate 4 was being dug. A critical appraisal of Tables 4-5 to 4-10 and Figures 4-14 to 4-16 might lead one to suppose that these large chunks along with a great many smaller ones apparently form in the lower profile at or above the water table, probably within the capillary fringe zone that seasonally fluctuates with the water table. But do they? If the concretions form at depth, why do they occur throughout the profiles, with only small ones in the upper parts? If they once formed higher in the profiles, perhaps when the water table was higher, why do large concretions occur only in the lower B_{ir} horizons? Why are some concretions exposed on the surface of the windows? Also, why do wind-polished anthropic flakes and stream polished gravels occur at depth in the profiles? To explain these observations and questions, it is hypothesized that the window soils have experienced mixing during their formational history.

Hypothesis of Animal-Caused Mixing: It is suggested that the mixing is caused by burrowing mammals, mainly rodents, that live in the Oceano soils, and that lived in them before they were buried by the Intermediate dunes and after their exposure as exhumation windows. In advance of expanding this hypothesis, it is suggested (because it is relevant to the hypothesis) that these windows are temporally ephemeral, that those present now may one day be again buried by further dune advances, and that many former windows are now re-buried. That this must occur is demonstrated by the geometry and movement physics of coalesced parabolic dunes. Individual dune fronts advance downwind as a united coalesced "front" of lobed, parabolic dunes leaving behind deflation blowouts in their connected upwind trailing arms. The present coalesced Intermediate dune front next to Marshallia Ranch (defined by a sinuous, near-continuous line of eucalyptus trees) with upwind deflation windows is the modern example. Brown (Chapter 5) has clearly demonstrated that small flakes dropped by Indians upwind on the dunes, or eroded from coastal or upwind middens, are polished (eolized) and moved by wind across the Modern and/or Intermediate dunes (when the latter are active). They may become buried in active sand enroute, or proceed across the dune and down the slipface onto the sub-dune soil where they are buried by the advancing dune. Stones small enough to be moved by wind must also experience eolization, transport, and burial. The process is somewhat tractor tread-like in analogy; when a window is subsequently formed by deflation within the arms of a parabolic dune, the flakes and pebbles become re-exposed on the surface. They may then be displaced downward passively

cm Depth	Weight(gm)/Number of Concretions by Size Classes (mm) of Long Axis, over Computed Average Weight/Concretion (in parentheses). 3-10[1]	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Wt./No.	Max. L/W Wt.[2]	Wt. Heaviest Conc. (gm)
0-20	3/26 (0.1)	41/26 (1.6)	106/27 (3.9)	89/8 (11.1)	20/1 (20)	-	-	-	259/88 (2.9)	47/34 20	20
20-40	1/9 (0.1)	24/15 (1.6)	75/18 (4.2)	124/12 (10.3)	28/1 (28)	-	-	-	252/55 (4.6)	48/47 28	28
40-60	1/7 (0.1)	8/6 (1.3)	59/12 (4.9)	28/4 (7.0)	39/2 (19.5)	71/2 (35.5)	43/1 (43)	-	249/34 (7.3)	63/32 44	44
60-80	-	-	23/4 (5.6)	45/4 (11.3)	11/1 (11.0)	-	-	-	79/9 (8.8)	44/30 11	11
80-100	1/3 (0.3)	8/5 (1.6)	48/9 (5.3)	96/9 (10.6)	30/2 (15.0)	-	-	-	183/28 (6.5)	41/20 10	20
100-120	-	-	-	-	-	-	-	89/1 (89.0)	89/1 (89.0)	78/55 89	89
Wt./No.	6/45 (0.1)	81/52 (1.6)	288/66 (4.4)	337/33 (10.2)	117/6 (19.5)	71/2 (35.5)	43/1 (44.0)	89/1 (89.0)	1032/206 (5.0)	-	-

1. Includes all conc[illegible]tions with lengths <10 mm that were retained on 3.2 mm (1/8 in.) wire hardware cloth.
2. Maximum length ([illegible] of long axis of longest concretion within the depth interval indicated/maximum width (mm) of that concretion, over its weight (gm).

Table 4-5. Ironstone (Plinthite) Concretion Measurements, Test Pit No. 1, MAB Window Site SBa-1170, Vandenberg Air Force Base, California.

cm Depth	Weight(gm)/Number of Concretions by Size Classes (mm) of Long Axis, over Computed Average Weight/Concretion (in parentheses). 3-10[1]	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	Wt./No.	Max. L/W Wt.[2]	Wt. Heaviest Conc. (gm)
0-20	1/11 (1.0)	11/5 (2.2)	94/36 (2.6)	399/33 (12.1)	-	30/2 (15.0)	39/1 (39.0)	-	-	574/78 (7.4)	60/45 39	39
20-40	1/5 (0.2)	4/3 (1.3)	88/12 (7.3)	191/16 (11.9)	79/3 (26.3)	122/3 (40.7)	-	-	61/1 (61.0)	546/43 (12.7)	81/41 61	66
40-60	436/3086 (0.1)	569/520 (1.1)	654/148 (4.4)	288/25 (11.5)	359/17 (21.1)	226/7 (32.3)	-	-	-	2532/3803 (0.7)	59/41 46	46
60-80	372/1975 (0.2)	574/398 (1.4)	506/115 (4.4)	297/31 (9.6)	197/10 (19.7)	116/3 (38.7)	93/1 (93.0)	87/1 (87.0)	-	2242/2534 (0.9)	73/57 87	93
80-100	20/3435 (0.01)	767/677 (1.1)	458/103 (4.5)	347/33 (10.5)	411/19 (21.6)	-	97/2 (48.5)	-	-	2100/4269 (0.5)	65/43 60	60
100-120	13/110 (0.1)	18/17 (1.1)	9/2 (4.5)	-	-	-	-	-	-	40/129 (0.3)	29/19 6	6
120-140	39/215 (0.2)	52/56 (0.9)	63/19 (3.3)	58/6 (9.7)	19/1 (19.0)	73/2 (36.5)	-	-	-	304/299 (1.0)	54/52 43	43
Wt./No.	882/8827 (0.1)	1995/1676 (1.2)	1872/435 (4.3)	1580/144 (11.0)	1065/50 (21.3)	567/17 (33.4)	229/4 (57.3)	87/1 (87.0)	61/1 (61.0)	8338/11155 (0.7)	-	-

1. Includes all concretions with lengths <10 mm that were retained on 3.2 mm (1/8 in.) wire hardware cloth.
2. Maximum length (mm) of long axis of longest concretion within the depth interval indicated/maximum width (mm) of that concretion, over its weight (gm).

Table 4-6. Ironstone (Plinthite) Concretion Measurements, Test Pit No. 2, MAB Window Site SBa-1170, Vandenberg Air Force Base, California.

cm Depth	Weight(gm)/Number of Concretions by Size Classes (mm) of Long Axis, over Computed Average Weight/Concretion (in parentheses). 3-10[1]	10-20	20-30	30-40	40-50	50-60	60-70	Wt./No.	Max. L/W Wt.[2]	Wt. Heaviest Conc. (gm)
0-15	-	-	-	-	-	-	-	-	-	-
15-20	13/89 (0.2)	56/53 (1.1)	7/2 (3.5)	-	20/1 (20.0)	-	-	96/145 (0.7)	41/28 20	20
20-40	88/525 (0.2)	219/209 (1.1)	176/39 (4.5)	61/4 (15.3)	46/2 (23)	-	-	590/779 (0.8)	49/32 32	32
40-60	130/682 (0.2)	211/185 (1.1)	178/38 (4.7)	178/19 (9.4)	12/1 (12.0)	52/1 (52.0)	54/1 (54.0)	815/927 (0.9)	63/39 54	54
60-80	90/511 (0.2)	216/187 (1.2)	221/49 (4.5)	171/14 (12.2)	56/3 (18.7)	45/1 (45.0)	-	799/765 (1.0)	53/52 45	45
80-100	101/594 (0.2)	199/209 (1.0)	213/54 (3.9)	132/12 (11.0)	21/1 (21.0)	17/1 (17.0)	-	683/871 (0.8)	50/28 17	21
100-120	31/218 (0.2)	88/92 (1.0)	74/18 (4.1)	15/2 (7.5)	114/6 (19.0)	96/2 (48.0)	-	418/338 (1.2)	59/53 46	51
120-140	28/180 (0.2)	78/77 (1.0)	63/17 (3.7)	44/5 (8.8)	41/2 (20.5)	-	-	254/281 (0.9)	45/24 17	24
140-160	30/225 (0.2)	82/86 (1.0)	47/13 (3.6)	19/3 (6.3)	-	35/1 (35.0)	40/1 (40.0)	253/329 (0.8)	63/44 40	40
Wt./No.	511/3024 (0.2)	1149/1098 (1.1)	979/230 (4.3)	620/59 (10.5)	310/16 (19.4)	245/6 (40.8)	94/2 (47.0)	3908/4435 (1.1)	-	-

1. Includes all concretions with lengths <10 mm that were retained on 3.2 mm (1/8 in.) wire hardware cloth.
2. Maximum length (mm) of long axis of longest concretion within the depth interval indicated/maximum width (mm) of that concretion, over its weight (gm).

Table 4-7. Ironstone (Plinthite) Concretion Measurements, Test Pit No. 3, MAB Window Site SBa-1170, Vandenberg Air Force Base, California.

	Percent			
Depth (cm)	sand (2-0.05mm)	silt (50-2μ)	clay (<2μ)	Horizons
0-10	93.3	2.1	4.6	A_{11}
10-20	93.0	6.4	0.6	
20-30	93.0	4.2	2.7	A_{12}
30-40	94.0	2.5	3.5	
40-50	94.0	5.0	1.0	
50-60	93.3	2.0	4.7	A_2
60-70	94.1	3.9	2.0	
70-80	94.0	3.5	2.5	
80-90	93.8	2.1	4.1	B_{ir}
90-100	93.9	3.1	2.4	
100-110	95.0	2.2	2.8	
110-120	95.4	1.7	2.9	
120-130	95.6	1.0	3.4	
130-140	96.1	1.4	2.5	C_g
140-150	95.5	1.7	2.8	

Table 4-8. MAB Window, VAFB-1: Physical Properties.

cm Depth	ppm P_1	pH	% OM	Meq/100 gm CEC	% BS	ppm/percent Potassium	Magnesium	Calcium	Sodium	mmhos/cm Sol. Salts	Horizons
0-10	23	5.9	8.3	11.4	83.1	101/2.3	210/15.3	1450/63.4	55/2.1	0.1	A_{11}
10-20	14	5.9	4.4	7.1	83.0	97/3.5	85/10.0	950/67.3	35/2.2	0.1	
20-30	13	6.1	2.3	6.8	86.0	129/4.9	95/11.7	900/66.7	42/2.7	0.1	
30-40	9	5.9	1.8	5.9	83.1	89/3.9	90/12.7	750/63.4	42/3.1	0.1	A_{12}
40-50	8	5.7	1.5	5.5	79.0	47/2.2	90/13.6	650/59.1	52/4.1	0.1	
50-60	8	5.7	1.0	5.1	78.9	30/1.5	110/17.9	550/53.8	67/5.7	0.1	
60-70	10	5.1	1.0	4.8	62.1	14/0.8	95/16.6	350/36.6	89/8.1	0.2	A_2
70-80	13	5.3	1.0	4.5	69.0	49/2.8	60/11.1	400/44.4	111/10.7	0.2	
80-90	24	5.7	0.8	3.1	78.9	64/5.4	60/16.3	300/49.0	58/8.2	0.1	
90-100	22	5.8	0.4	2.7	80.9	71/6.7	65/20.0	250/46.2	50/8.0	0.1	B_{ir}
100-110	10	5.5	0.4	2.7	74.1	60/5.8	45/14.1	250/47.0	44/7.2	0.1	
110-120	8	5.9	0.2	2.3	83.0	46/5.1	45/16.2	250/54.0	41/7.7	0.1	
120-130	6	6.1	0.2	2.2	86.0	37/4.3	40/15.3	250/57.2	46/9.2	0.1	
130-140	6	6.2	0.1	1.7	88.0	25/3.8	35/17.1	200/58.7	33/8.4	0.1	C_R
140-150	5	6.3	0.1	1.7	89.5	22/3.3	40/19.2	200/57.7	37/9.3	0.2	

Table 4-9. MAB Window, VAFB-1: Chemical Properties.

cm² Depth	Weight(gm)/Number of Concretions by Size Classes (mm) of Long Axis, over Computed Average Weight/Concretion (in parentheses). 3-10[1]	10-20	20-30	30-40	40-50	50-60	60-70	70-80	Wt./No.	Max. L/W Wt.[2]	Wt. Heaviest Conc. (gm)
0-15	ND[3]	70/55 (1.3)	24/5 (4.8)	62/5 (12.4)	18/1 (18.0)	-	-	-	174/66 (2.6)	40/30 18	18
15-30	ND[3]	61/52 (1.2)	53/12 (4.4)	34/4 (8.5)	47/3 (15.7)	31/1 (31.0)	-	-	226/72 (3.1)	52/36 31	31
30-45	ND[3]	46/40 (1.2)	74/22 (3.4)	72/7 (10.3)	79/3 (26.3)	74/2 (37.0)	16/1 (16.0)	-	361/75 (4.8)	61/26 16	42
45-60	ND[3]	29/34 (0.9)	37/10 (3.7)	58/6 (9.7)	81/5 (16.2)	93/2 (46.5)	42/1 (42.0)	-	340/58 (5.9)	65/63 42	61
60-75	ND[3]	24/32 (0.8)	34/8 (4.3)	37/3 (12.3)	100/5 (20.0)	-	118/2 (59.0)	-	313/50 (6.3)	69/67 57	61
75-90	ND[3]	30/38 (0.8)	35/10 (3.5)	35/3 (11.7)	32/2 (16.0)	104/3 (34.7)	55/1 (55.0)	242/3 (81.0)	533/60 (8.9)	79/68 107	107
90-105	ND[3]	119[4]/125[4] (1.0)	12/4 (3.0)	32/4 (8.0)	-	-	92/1 (92.0)	-	255/134 (1.9)	64/45 92	92
105-120	ND[3]	63[4]/100[4] (0.6)	4/2 (2.0)	-	-	-	-	-	67/102 (0.7)	23/1 2	2
120-135	-	-	-	-	-	-	-	-	-	-	-
Wt./No.	-	442/476 (0.9)	273/73 (3.7)	330/32 (10.3	357/19 (18.8)	302/8 (37.8)	323/6 (53.8)	242/3 (81.0)	2269/617 (3.7)		

1. Includes all concretions with lengths <10 mm that were retained on 3.2 mm (1/8 in.) wire hardware cloth.
2. Maximum length (mm) of long axis of longest concretion within the depth interval indicated/maximum width (mm) of that concretion, over its weight (gm).
3. No data (not determined).
4. Most of the concretions at this depth are extremely friable and are comprised of very weakly cemented sand; during handling *almost all the larger ones desintegrated into sand*, and also smaller pieces, which in part accounts for the large number at this depth (the 119 gm fraction, for example, is what remained from larger concretions that were originally collected in the field; after further handling and measuring them in the laboratory they weighed only 86 gm a loss of 28% as sand).

Table 4-10. Ironstone (Plinthite) Concretion Measurements, VAFB-1 50 CM² Test Pit (East) MAB Window Site SBa-1170, Vandenberg Air Force Base, California.

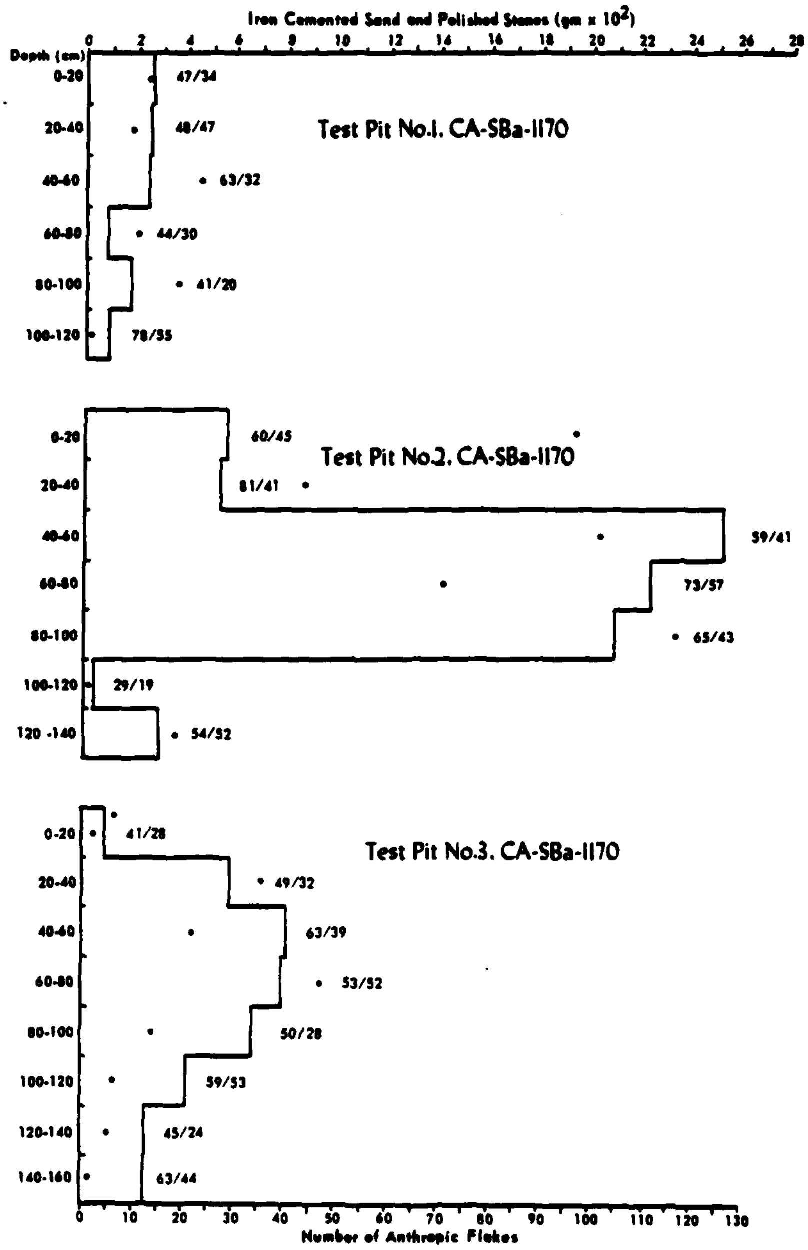


Figure 4-13. Analyses of Iron-Cemented Concretions with Depth in Three Archaeological Pits, Site SBa-1170, Vandenberg Air Force Base, California.

The histogram represents total weight of concretions with depth. The slashed numbers (e.g., 47/34) give the maximum length (mm) of long axis of longest concretion over the maximum width (mm) of that concretion within the depth interval indicated. The dot indicates the total weight of polished stones at each depth increment (data from Tables 4-5 through 4-7).

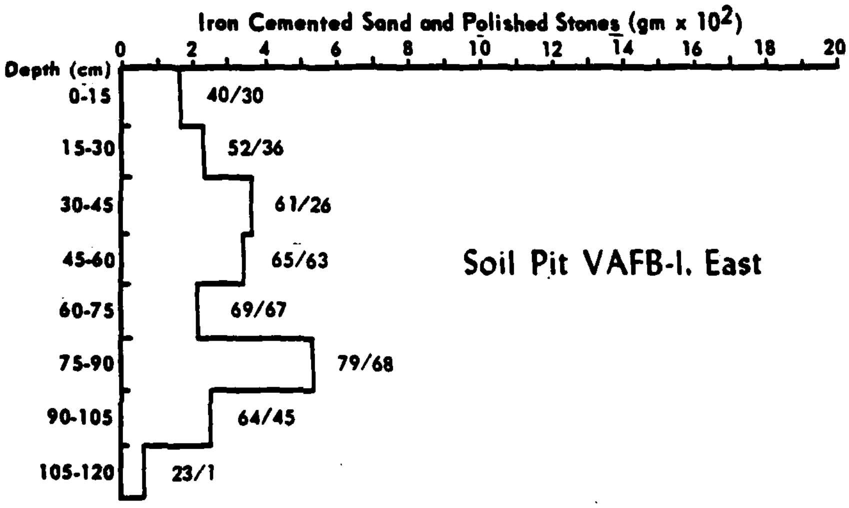


Figure 4-14. Analyses of Iron-Cemented Concretions with Depth in Soil Pit VAFB-1, East, Vandenberg Air Force Base, California.

The histogram represents total weight of concretions with depth. The slashed numbers (e.g., 47/34) give the maximum length (mm) of long axis of longest concretion over the maximum width (mm) of that concretion within the depth interval indicated (data from Table 4-10).

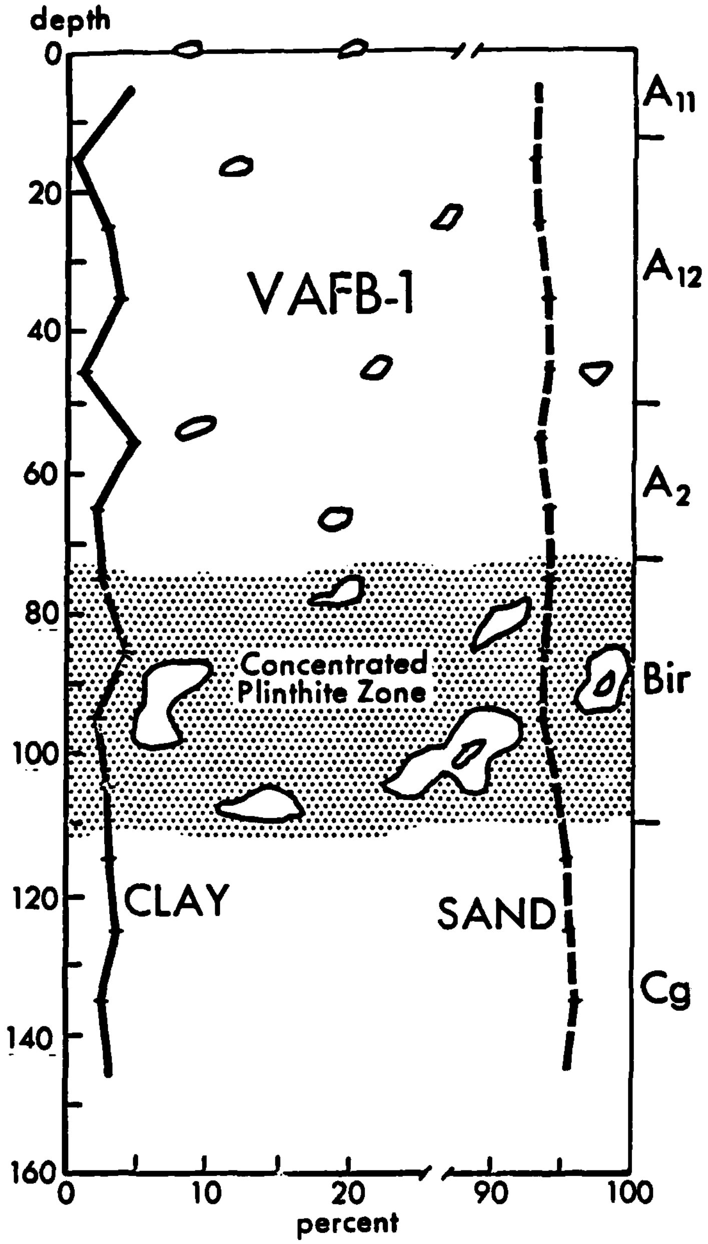


Figure 4-15. Particle Size Analyses of Profile VAFB-1 of Sk Soil on Windows of Exhumed Oceano Surface with Depth and by Horizon Showing Relative Sizes of Iron-Cemented Sand Concretions in Plinthite Zone (Data from Table 4-8).

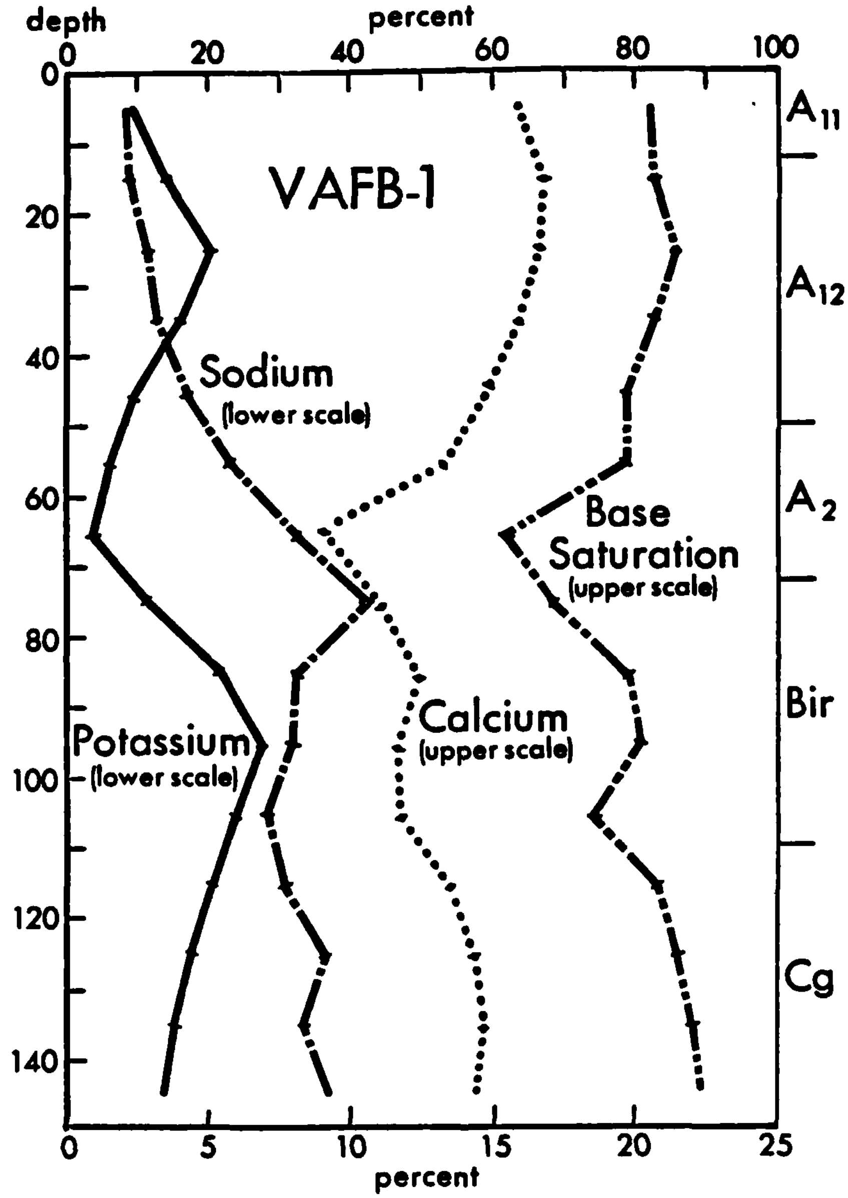


Figure 4-16a. Chemical Data of Profile VAFB-1 of Sk Soil in Window of Exhumed Oceano Surface with Depth and by Horizon (Data from Table 4-9).

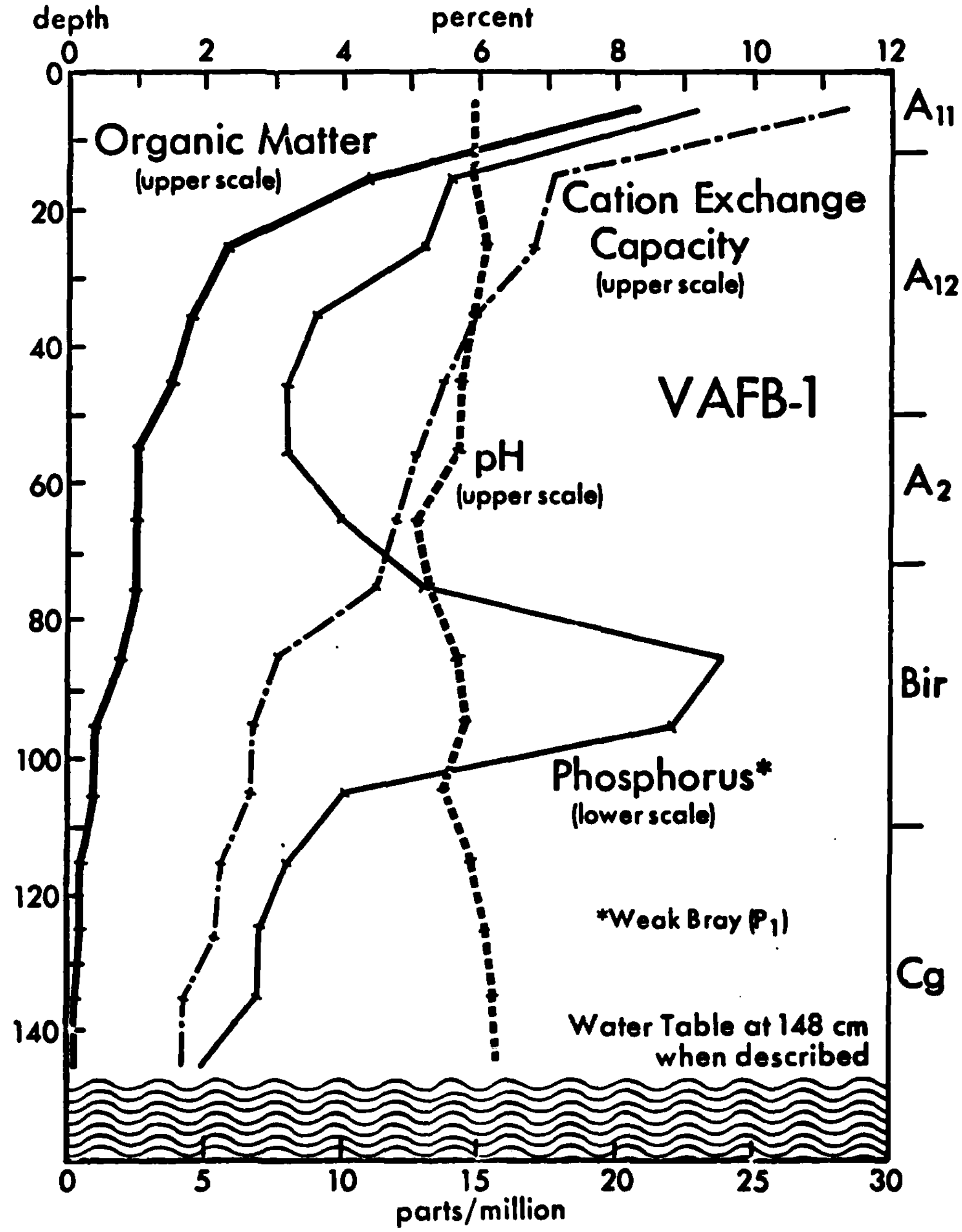
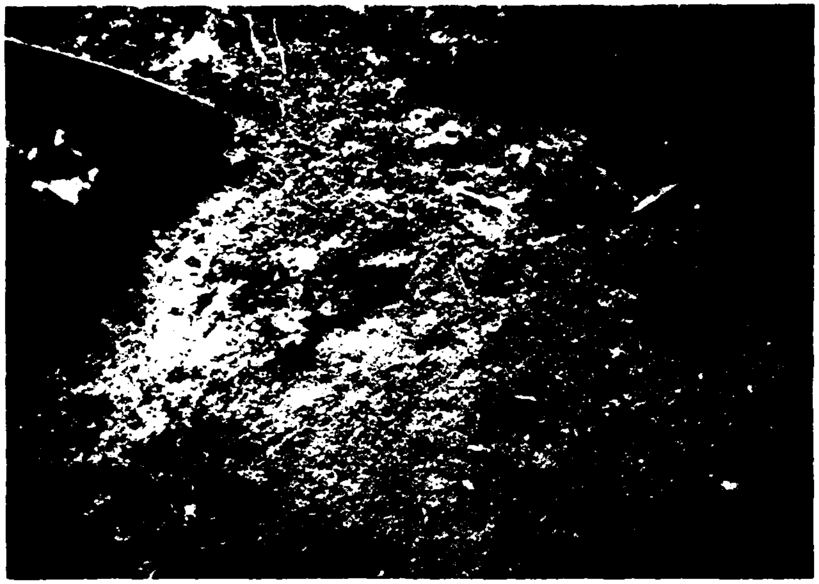


Figure 4-16b. Chemical Data of Profile VAFB-1 with Depth and by Horizon (Data from Table 4-9).



a

c

b

Plate 4.

Close up (a) of iron cemented sandstone concretion below and to right of trowel tip in wall of Pit VAFB-1. Photo (b) of plinthite removed from pit (c) at VAFB-1, in old dune surface in "window" of Intermediate San Antonio dunefield.

Table 4-11. Ranking of Anthropic Flakes Removered from Excavations of Archaeological Pits, Site SBa-1170, Vandenberg Air Force Base, California. (M. Glassow, Personal Communication, January 1983.)

Rank	Degree of Polish	Size Classes (Inches) Greater Than 1/2 Inch	1/4 to 1/2 Inch	1/8 to 1/4 Inch
1	unpolished	1	3	0
2	slightly polished	4	4	1
3	moderately polished	6	10	19
4	severely polished	10	36	45

through the action of rodent spoil that is intermittently piled on the soil surface. The hypothesized stepwise process is shown in Figure 4-17. This figure shows a hypothetical situation where the parabolic Intermediate dune advances over Old dune terrain (Oceano soil) in a given period of time (T-0 to T-1). Small stones and anthropic flakes are eolized and moved by the wind across the surface of the Intermediate dune, down its slipface, and subsequently buried. Non- or weakly-eolized manuports and stones on the Oceano surface are vertically mixed by active bioturbation; they, too, get buried by the advancing Intermediate dune lobe. When windows of the Old dune (Oceano) surface are exhumed by deflation, burrowing animals re-colonize and bioturbate the Oceano soils and displace these materials downward, but concommitantly displace subsoil iron cemented sand concretions and underlying fluvial gravels upward to the surface.

In Figure 4-17, the hypothetical dynamic histories of seven artifacts (1-7) are traced by noting their relative vertical positions through time (T0 to T1). For example, artifacts 1 through 5, originally exposed on the Oceano soil surface, were buried by an advancing Intermediate dune lobe. Number 1 became exhumed by deflation and "moved" downwards via bioturbation. Artifact 2 then followed suit, and so on, number 5 being exhumed last and therefore vertically bioturbated least. Conversely, at time T0 artifact 7 was buried, but by time T1 it had been bioturbated upward to the surface.

The scenario just presented is for the area circumscribed by Intermediate dune advances, but is it possible that the same processes were at work when the Old dunes were deposited during early to mid Holocene time? This question is raised by anthropic flakes recovered at various levels at the Gate House site (SBa-1036; Figure 4-9). This site is in Old dune terrain downwind of the Intermediate dunes and not affected by them. Abundant evidence of rodent mixing is present at the site (see Plate 5).

Were the flakes deposited in the various levels by the wind during early to mid Holocene time in the fashion described above by Brown for the Intermediate dunes, or were they deposited directly by humans on the Old dune surface and subsequently displaced downward by rodents? Neither possibility is mutually exclusive, but the fact that most of the flakes were not wind polished (Table 4-12) supports the latter interpretation.

To test the validity of the idea that soil-burrowing animals can not only displace artifacts downward in these soils, but in the process also move small concretions and pebbles upwards (and also to learn what the maximum size and weight limits are of the materials they move), an area of study was selected on the Signorelli Ranch north of San Miguelito Canyon Road, just off the south Vandenberg base limits in upper Honda Canyon. Here southern pocket gophers (Thomomys umbrinus) have thoroughly churned a residual talus apron that consists of very gravelly soil (Plate 4-6). The soil profile was exposed in a borrow pit made by the owner. A "stone zone" is present in the soil profiles, which consist of large stones (less than 6 to 7 cm diameter) in a matrix of soil and smaller stones. The large stones, mainly fist-sized and larger, are obviously too large to be moved by pocket gophers whose burrows are about 6 cm in diameter. They are, however, not too large to be moved by larger ground-digging animals such as badgers (Taxidea taxus) and California ground squirrels (Spermophilous [Citellus] beecheyi) that live in the Vandenberg area; on the Signorelli property no ground squirrel activity was noted, but a few badger holes were present (though

Table 4-12. Ranking of Anthropic Flakes Removered from Excavations of Archaeological Pits, Site SBa-1036, Vandenberg Air Force Base, California. (M. Glassow, Personal Communication, January 1983.)

		Size Classes (Inches)		
Rank	Degree of Polish	Greater Than 1/2 Inch	1/4 to 1/2 Inch	1/8 to 1/4 Inch
1	unpolished	54	140	448
2	slightly polished	0	0	9
3	moderately polished	0	0	3
4	severely polished	0	0	0

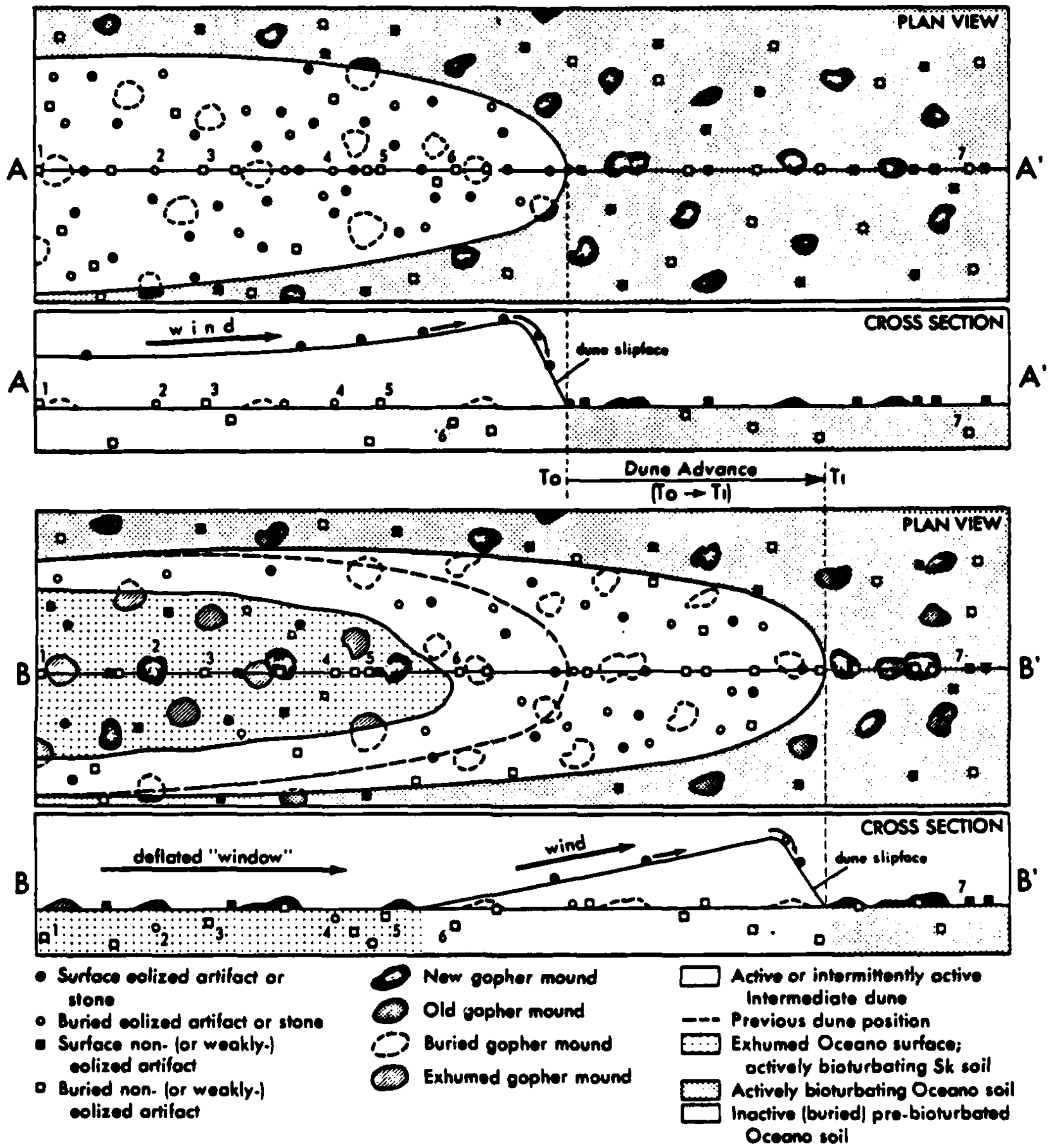


Figure 4-17. Hypothetical Model of Integrated Processes of Artifact Eolization and Mixing on Intermediate and Oil Dunes, Based on Brown's Work (see Chapter 5) and Concepts Developed in This Study. Thy Dynamic Histories of Seven Artifacts (1-7) are Traced from Time 0 (TO) to Time 1 (T1). See Text for Explanation.

a

b

Plate 5. Photo (a) is of profile VAFB-1 developed in oil dune window of Intermediate dunefield. The B_{ir} horizon is clearly apparent. Photo (b) shows bioturbated wall of archaeological pit SBa-1036, Unit 9 (Gate House Site). This soil is developed in old dune (photo courtesy M. Glassow).

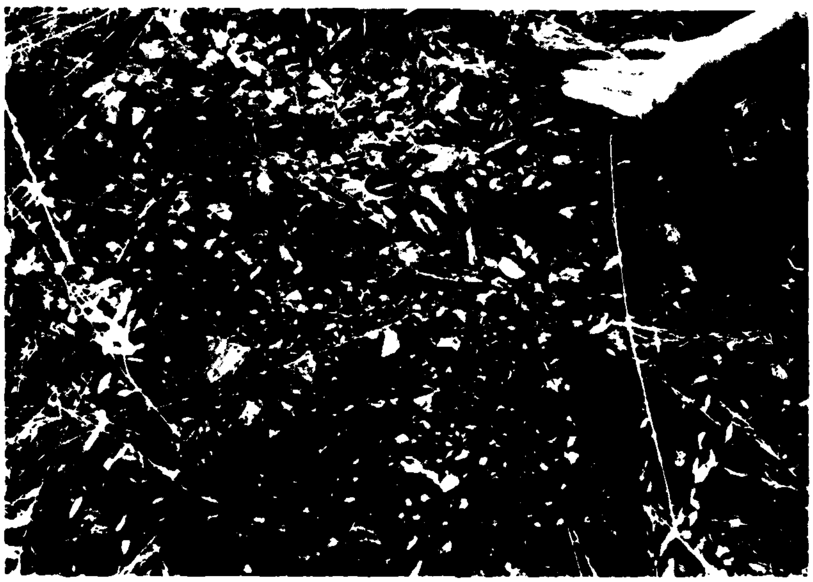


Plate 6. Upper photo shows side wall profile of Gopher Gravels borrow pit. Note "stone zone" below top of shovel handle to metal scoop of shovel. Lower photo shows a gravel rich gopher mound. Both photos taken at Signorelli Ranch, San Miguelito Canyon Road, Lompoc, California.

none was observed in the gravel aprons). It was hypothesized that because gophers cannot move the larger stones, they would gradually be "lowered" to a general level in the profile owing to the translocation to the surface of the smaller stones and soil material that gophers do move. Given enough time a stone line, or in this case, a "stone zone" will be produced at or near the lower limits to which gophers burrow. (The same process has been attributed to the formation of buried stone lines in the Point Conception area several kilometers to the south, and in other areas of the world [Johnson 1981; Johnson and Watson-Stegner n.d.]). The model in Figure 4-18 is offered to explain how such stone zones and stone lines form through the activity of burrowing rodents, and how manuports can be "lowered" in the process. The model in Figure 4-19 is offered to explain how iron-cemented concretions that possibly form only in the subsoil (within the zone of fluctuating ground water) can be regularly translocated upward by burrowing rodents and occasionally by larger surface-digging mammals (e.g., badgers, coyotes).

A further test of the animal-mixing hypothesis would be achieved if a number of gopher debris mounds were examined, sieved, and particle size analyzed. If gophers move stones no larger than 6 cm or 7 cm in length, the stones in the gopher mounds should be this size or smaller. To this end, seven gopher mounds from the gravel aprons of the Signorelli Ranch were size sieved, and the stones from each size class counted (Table 4-13). Additionally, stones from four of the seven mounds were weighed, their long axes measured, and computed (Table 4-14). Several tens of thousands of stones were thus counted, weighed, measured and computed. The maximum length of any stone in the gopher mounds was 6.1 cm, and the maximum weight of any stone was 36 gm. Thus, though this is but a limited study of only seven gopher mounds, the data suggest that gophers move only small stones less than about 36 gm weight and about 6 cm or so long. One supposes that the diameter of their burrows, being about 6 cm, is the principal limiting factor. They apparently do not and cannot move large stones of a size like those in the "stone zones" of these soils.

If gophers mix and "size-sort" stones to the degree indicated in the Signorelli Ranch soils, then other soil properties, such as percent organic matter and clay, should also reflect such mixing. That is, the normal horizons (A, B, C) that characterize most soils might be absent or minimally expressed due to mixing. To test this notion, three profiles of the borrow pit were described, sampled, and subjected to laboratory analysis (Tables 4-15 through 4-20). Some of these data are graphed in Figure 4-20. The data indicate minimal horizonation of these soils and support the mixing hypothesis. Pocket gopher burrows were observed at a depth of more than 1 m in the side walls of the Signorelli borrow pit, and at the Gate House Site infilled rodent burrows were present to at least 1.4 m depth (M. Glassow, personal communication, 1982). Further, on South Vandenberg, certain archaeological sites, notably SBa-931, revealed high levels of faunal mixing.

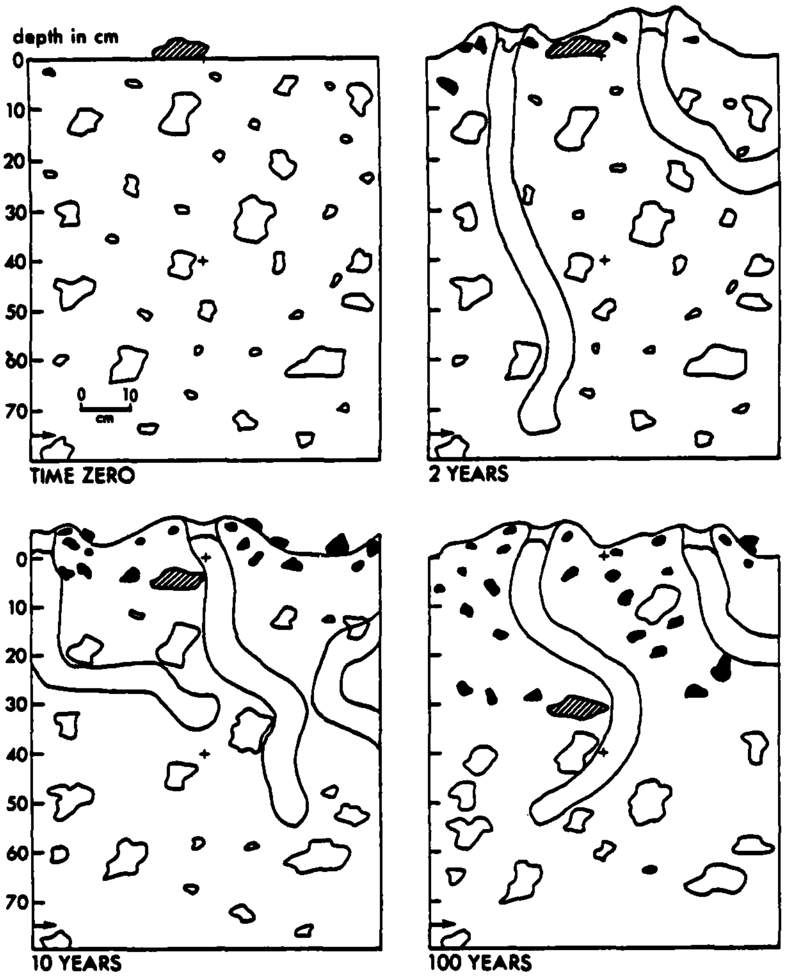


Figure 4-18. Model of Stone Line and Stone Zone Formation by Burrowing Activity of Pocket Gophers Based on Hypothetical Sequence of Events and Timing.

For simplicity, time zero assumes uniform distribution of stones of different sizes. Large hatched stone is a manuport dropped by humans. The large stone at 10 cm depth in the 100 year profile was dug from the stone zone by a large mammal (badger?) and was then buried by pocket gophers. Stones that have diameters 6-7 cm or less and that have been translocated to surface at least once by gophers are shown in black. The two crosses are constant reference points. Arrow indicates maximum depth (75 cm) that gophers burrow in this particular soil (in other soils they may burrow deeper, or less deep). Eventually a 40 cm thick stone zone forms (at 30-75 cm). Zone of complete faunalturbation after 100 years is from surface to 30 cm depth, but will continue to expand downward to maximum depth of burrowing. (Burrow geometry and depth as shown are not meant to suggest their average character; burrows also may not terminate as shown but may extend away from or toward viewer.)

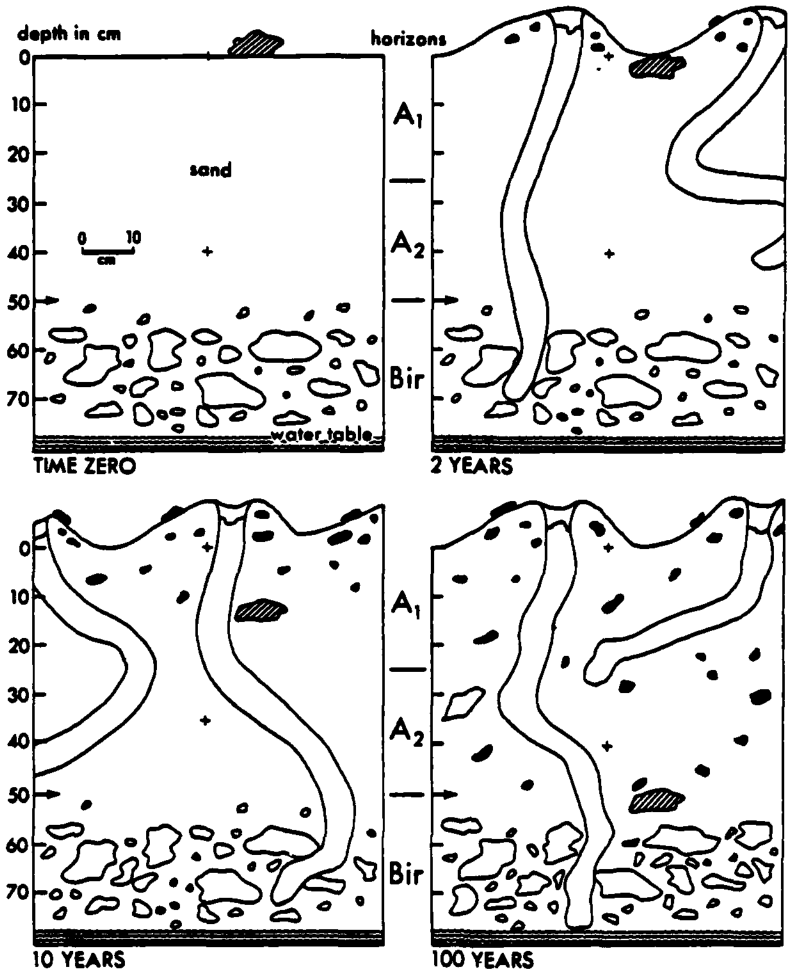


Figure 4-19. Model of Vertical Dispersion of Iron-Cemented Concretions from B_{ir} Horizon into A_1 and A_2 Horizons of Sandy Soils by Faunalturbation (Mainly Rodents) Based on Hypothetical Sequence of Events, Timing, and Horizonation.

In this model, the concretions are assumed to form in the capillary fringe zone above an annually fluctuating water table. The arrow marks the mean uppermost limit of the fluctuating capillary fringe zone. Concretions with diameters 6-7 cm or less and which have been translocated to the surface at least once by pocket gophers are shown in black. The two crosses are constant reference points. The hatched stone is a manuport dropped by humans. The large concretion in the A_2 horizon of the 100 year profile is too big for pocket gophers to have moved, and presumably was dug from Bir horizon by a larger mammal (ground squirrel or coyote?). In this model, the concretions are assumed to continually form through time in the Bir horizon by iron oxide precipitation within the capillary fringe zone. (Burrow geometry and depth as shown are not meant to suggest their average character; burrows also may not terminate as shown but may extend away from or toward viewer.)

			Stones			Soil		
Sieve Openings mm(in.)	25(1)	19(3/4)	12.5(1/2)	9.5(3/18)	4(5/32)	<4	Totals	Mound
Weight (gm)	93	245	520	234	683	1164	2939	1
Number[8]	3	24	145	180	4025	nd[2]	4377[3]	
Weight	0	71	165	97	223	426	982	2
Number	0	7	50	74	1334	nd[2]	1465[3]	
Weight	65	234	431	314	752	1477	3273	3
Number	3	23	125	233	4275	nd[2]	4659[3]	
Weight	98	343	441	235	454	426	1997	4
Number	3	29	115	172	2175	nd[2]	2494[3]	
Weight	682	596	1448	682	1619	2442	7469	5
Number	20	48	316	490	nd[2]	nd[2]	874[4]	
Weight	71	128	398	256	738	1505	3096	6
Number	4	14	92	169	nd[2]	nd[2]	279[4]	
Weight	28	85	256	170	256	398	1193	7
Number	2	7	52	96	nd[2]	nd[2]	157[4]	
Total weight	1037	1702	3659	1988	4725	7838	20949	
Total number	35	152	895	1414	11809[5]	nd[2]	14305[6]	
Ave. weight/mound	148	243	523	284	675	1120	2993	
Ave. number/mound	5	22	128	202	2952[5]	nd[2]	2044[7]	

1. Maximum length of longest stone: 61 mm.
2. nd = no data (not determined).
3. The <4 mm fractions not available for any of the seven mounds.
4. The <9.5 mm fractions not available for mounds 5-7.
5. Represents mounds 1-4 only.
6. Total minus fractions indicated in footnotes 2, 3, & 4.
7. Average number of stones for mounds 1-4 is 3249, and for mounds 5-7 is 437 (see footnotes 2,3,4).
8. Values indicate number of stones held on sieves.

Table 4-13. Size, Number, and Weight (gm) Analyses of Stone Contents, and Soil Weight of Seven Gopher Mounds, Signorelli Ranch, San Miguelito Canyon Road, Lompoc, California.

Mound	4-10[1]	10-20	20-30	30-40	40-50	50-60	60-70	Wt./No.	Max. L/W Wt.[2]	Wt. Heaviest Stone (gm)
	Weight(gm)/Number of Stones by Stone Size Classes (mm) of Long Axis, Over Computed Average Weight/Concretion (in parentheses).									
No. 1	294/3106 (0.1)	584/1088 (0.5)	426/132 (3.2)	279/39 (7.2)	131/10 (13.1)	36/1 (36.0)	25/1 (25.0)	1775/4377 (0.4)	61/36 25	25
No. 2	120/1120 (0.1)	176/275 (0.6)	175/60 (2.9)	59/7 (8.4)	26/3 (8.7)	-	-	556/1465 (0.4)	43/21 6	16
No. 3	329/3213 (0.1)	642/1250 (0.5)	492/157 (3.1)	242/34 (7.1)	57/4 (14.3)	-	34/1 (34.0)	1796/4659 (0.4)	60/45 34	34
No. 4	206/1612 (0.1)	433/702 (0.6)	385/130 (3.0)	365/41 (8.9)	89/6 (14.8)	65/2 (32.5)	28/1 (28.0)	1571/2494 (0.6)	60/25 28	36
Wt.No.	949/9051 (0.1)	1835/3315 (0.6)	1478/479 (3.1)	945/121 (7.8)	303/23 (1[illegible]2)	101/3 (33.7)	87/3 (29.0)	4749/3944 (1.2)	-	-

1. Includes all stones with lengths <10 mm that were held on a 4 mm sieve.
2. Maximum length (mm) of long axis of longest stone/maximum width (mm) of that stone, over its weight (gm).

Table 4-14. Analyses of Four Stony Pocket Gopher Mounds, Signorelli Ranch, San Miguelito Canyon Road, Lompoc, California.

	Percent			
Depth (cm)	sand (2-0.05mm)	silt (50-2μ)	clay (<2μ)	Horizons
0-10	52.7	19.6	25.3	
10-20	44.6	25.2	27.5	
20-30	45.7	19.4	31.8	
30-40	39.8	22.5	34.3	A_{11}
40-50	39.5	28.1	32.4	
50-60	40.2	27.6	32.2	
60-70	40.4	27.3	32.3	
70-80	39.7	27.5	32.8	
80-90	40.4	25.4	34.2	A_{12}
90-100	40.5	27.1	32.4	
100-110	40.1	25.4	34.5	A_3
110-120	36.6	7.0	-	

Table 4-15. Gopher-1: Physical Properties.

cm Depth	ppm P_I	pH	% OM	Meq/100 gm CEC	% BS	ppm/percent Potassium	ppm/percent Magnesium	ppm/percent Calcium	ppm/percent Sodium	mmhos/cm Sol. Salts	Horizons
0-10	59	6.2	9.1	23.1	88.0	710/7.9	375/13.5	3000/65.0	83/1.6	0.3	A_{11}
10-20	38	6.1	6.5	22.1	86.0	340/4.0	335/12.7	3000/68.0	72/1.4	0.1	
20-30	38	6.0	5.3	21.5	85.0	201/2.4	295/11.4	3000/69.7	74/1.5	0.1	
30-40	40	6.1	4.6	24.0	86.0	146/1.6	320/11.1	3450/71.9	80/1.4	0.1	
40-50	36	6.2	4.1	22.7	88.0	104/1.2	330/12.1	3300/72.8	97/1.9	0.1	
50-60	34	6.3	4.0	22.9	89.5	97/1.1	335/12.2	3400/74.2	104/2.0	0.1	
60-70	41	6.3	3.1	24.1	89.5	107/1.1	370/12.8	3550/73.6	107/1.9	0.1	A_{12}
70-80	41	6.4	3.0	21.9	91.0	81/0.9	365/13.9	3250/74.1	106/2.1	0.1	
80-90	41	6.4	2.9	21.1	91.0	98/1.2	380/15.0	3050/72.4	113/2.3	0.1	
90-100	38	6.6	2.6	22.5	94.0	99/11.1	415/15.3	3400/75.4	111/2.1	0.1	
100-110	44	6.5	2.0	18.6	82.5	74/1.0	420/18.8	2600/69.9	116/2.7	0.1	A_3
110-120	44	6.6	1.3	17.5	84.0	65/0.9	490/23.3	2350/67.0	114/2.8	0.1	

Table 4-16. Gopher-1: Chemical Properties.

	Percent			
Depth (cm)	sand (2-0.05mm)	silt (50-2μ)	clay ($<2\mu$)	Horizons
0-15	48.5	25.8	25.7	
15-30	43.6	29.0	27.4	
30-45	41.1	27.4	31.5	A_{11}
45-60	41.0	26.4	32.4	
60-75	41.8	26.1	32.1	
75-90	43.3	29.4	-	
90-105	41.1	28.0	30.9	A_{12}
105-120	38.6	26.7	34.7	
120-135	41.2	27.4	31.4	
135-150	41.7	26.6	31.7	A_3
150-165	44.1	31.3	24.6	

Table 4-17. Gopher-2: Physical Properties.

cm Depth	ppm P_1	pH	% OM	Meq/100 gm CEC	% BS	ppm/percent Potassium	ppm/percent Magnesium	ppm/percent Calcium	ppm/percent Sodium	mmhos/cm Sol. Salts	Horizons
0–15	38	6.0	5.4	20.9	85.0	400/4.9	290/11.6	2800/66.9	79/1.6	0.2	
15–30	39	6.0	4.4	25.4	85.0	147/1.5	340/11.1	3600/70.8	90/1.5	0.2	
30–45	44	6.1	3.9	26.1	86.0	106/1.0	365/11.7	3700/70.9	145/2.4	0.1	A_{11}
45–60	43	6.2	4.8	25.6	88.0	91/0.9	360/11.7	3750/73.2	127/2.2	0.1	
60–75	41	6.3	4.8	24.5	89.5	84/0.9	410/14.0	3550/72.5	121/2.1	0.1	
75–90	46	6.1	4.9	24.4	86.0	104/1.1	380/13.0	3400/69.7	122/2.2	0.1	
90–105	44	6.3	4.3	25.0	89.5	93/1.0	430/14.3	3600/72.0	124/2.2	0.1	A_{12}
105–120	45	6.5	3.2	22.7	92.5	76/0.9	450/16.5	3250/71.5	190/3.6	0.1	
120–135	40	6.6	2.8	20.7	94.0	71/0.9	440/17.7	3000/72.5	136/2.9	0.1	
135–150	40	6.6	2.4	19.1	94.0	64/0.9	420/18.3	2750/71.9	132/3.0	0.1	
150–165	38	6.7	2.1	19.1	95.5	71/0.1	420/18.3	2800/73.3	130/3.0	0.1	A_3

Table 4-18. Gopher-2: Chemical Properties.

	Percent			
Depth (cm)	sand (2-0.05mm)	silt (50-2μ)	clay (<2μ)	Horizons
0-15	59.7	20.0	20.3	
15-30	55.4	24.3	20.3	A_{11}
30-45	52.1	21.6	26.3	
45-60	45.4	25.0	29.6	
60-75	45.4	24.1	30.5	
75-90	43.7	23.8	32.5	A_{12}
90-105	41.2	25.5	33.3	
105-120	42.5	25.3	32.2	
120-135	43.0	23.1	33.9	A_3
135-150	40.7	26.0	33.3	

Table 4-19. Gopher-3: Physical Properties.

cm Depth	ppm P_1	pH	% OM	Meq/100 gm CEC	% BS	ppm/percent Potassium	ppm/percent Magnesium	ppm/percent Calcium	ppm/percent Sodium	mmhos/cm Sol. Salts	Horizons
0–15	37	6.3	6.6	21.4	89.5	850/10.2	345/13.5	2750/64.3	74/1.5	0.1	
15–30	29	6.4	6.4	22.7	91.0	810/9.1	320/11.7	3100/68.2	100/1.9	0.1	A_{11}
30–45	31	6.3	6.4	23.5	89.5	920/10.0	350/12.4	3100/65.9	62/1.1	0.1	
45–60	36	6.5	6.1	26.3	92.5	999/9.7	455/14.4	3550/67.4	58/1.0	0.1	
60–75	44	6.5	6.5	26.4	92.5	999/9.7	365/11.5	3700/70.1	67/1.1	0.1	
75–90	47	6.6	7.2	26.5	94.0	999/9.7	370/11.6	3800/71.6	70/1.1	0.1	
90–105	45	6.6	7.2	25.7	94.0	890/8.9	380/12.3	3650/71.0	109/1.8	0.1	A_{12}
105–120	41	6.7	5.2	23.1	95.5	560/6.2	355/12.8	3450/74.6	104/2.0	0.1	
120–135	39	6.8	3.9	21.1	97.0	460/5.6	365/14.4	3150/74.6	114/2.3	0.1	A_3
135–150	32	6.8	2.1	18.6	97.0	370/5.1	365/16.4	2700/72.8	116/2.7	0.1	

Table 4-20. Gopher-3: Chemical Properties.

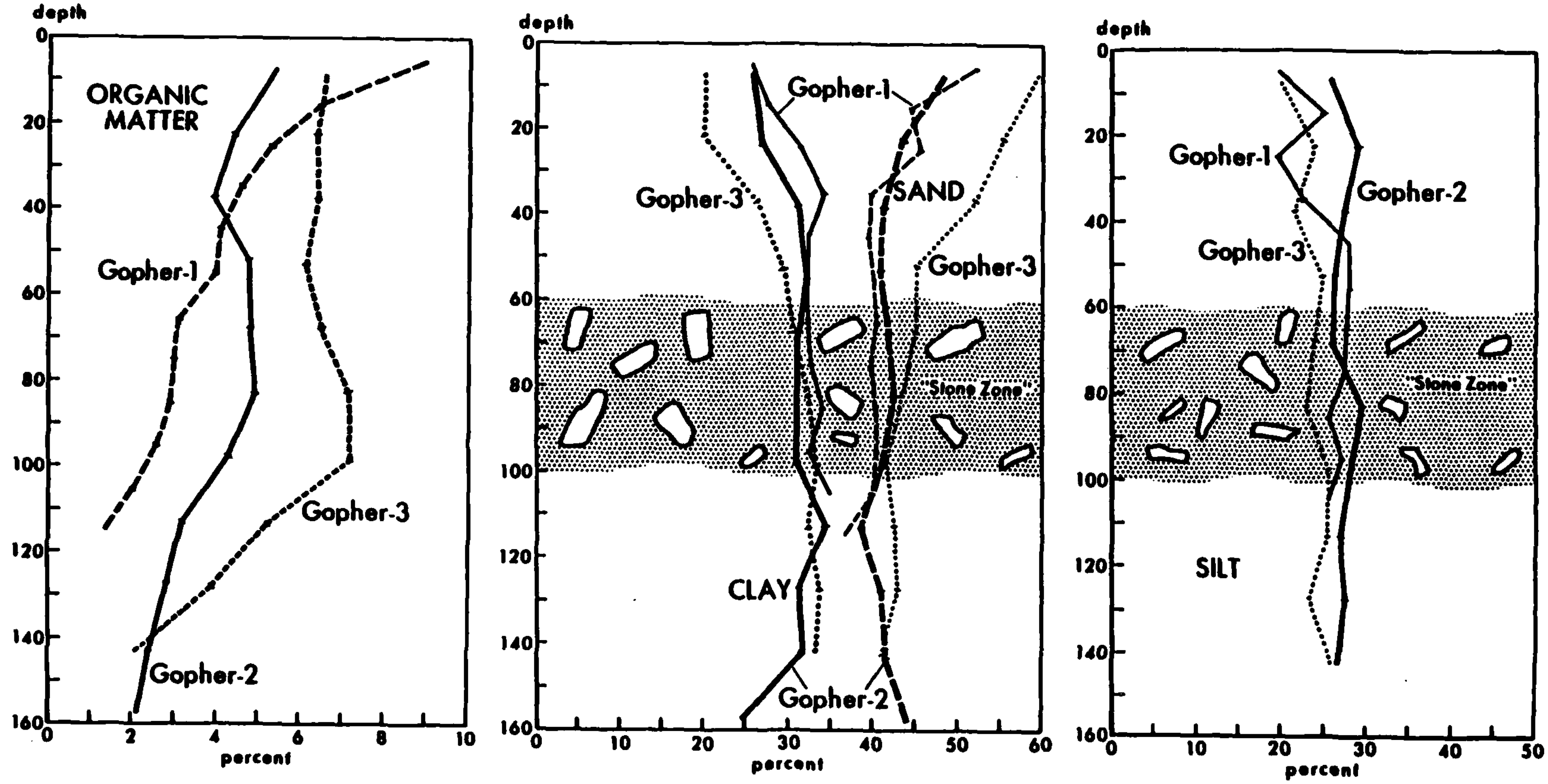


Figure 4-20. Depth Functions and Percents of Organic Matter and Particle *Size (Sand, Silt, Clay) of Three Profiles* (Gopher 1-3) at Graval Borrow Pit pn Signorelli Ranch, Upper San Miguelito Canyon Road, Lompoc, California. (Date from Tables 4-16 through 4-20).

Some idea of the number of gophers that can inhabit local soils in disturbed areas was provided by Mike Benedict, botanist-owner of Sanford-Benedict winery on Santa Rosa Road, Lompoc, and former manager of the University of California Research Station, Santa Cruz Island, California. Over a 2-1/2 year period between 1975 to 1977, about 3,700 pocket gophers were trapped by Benedict and his foreman (Larry Signorelli) on a 110 acre plot. Though the number averaged between 1,100 to 1,300 per season, about 2,100 were trapped during the first season alone.

Voles, ground squirrels, badgers, gray foxes, and coyotes, all of which are soil diggers and live on Vandenberg (Coulombe and Cooper 1976), can also move materials to the surface. But, excepting ground squirrels and possibly voles, (for what it is worth, three dead California Voles were found in pit VAFB-1 in late November, 1982 [the pit had been left open since late July 1982]) the relative frequency of their burrows was observed to be significantly lower than pocket gophers. Pocket gophers and ground squirrels are present in many habitats on Vandenberg (Coulombe and Mahrdt 1976), but seem to thrive in disturbed areas and are particularly common in grasslands. This is important because their present distribution and densities (and thus their relative roles in bioturbation), may be quite different from their natural, pre-European distributions and densities. That is, the relative role of these animals in mixing soil now at a given locality may not have been the norm in the past, and vice versa.

Ground squirrels and their mounds occur in abundance on the main headquarters portion of North Vandenberg, (for example, at the intersection of Ocean View Blvd., Airfield and Washington Roads), where they were observed to contain stones and iron-cemented concretions that were fist-sized and larger. So, while gophers appear to be present in greater numbers, ground squirrels are also important soil mixing vectors. In fact, ground squirrels on Marshallia Ranch were considered to be such pests in the early part of this century that extermination conditions were written into lease holdings (see Appendix II). Further, they are <u>the</u> major pest animal today on parts of North Vandenberg. Their importance in bioturbation needs to be assessed in the study area to at least the level that the pocket gophers were assessed, but time did not allow it for this study.

Application of these various observations to the Oceano soils on the Old dune surface east of Marshallia Ranch headquarters, and to the deflationally modified windows (Sk) soils to the west in the Intermediate dunes, is revealing. At VAFB-1 (Table 4-10) the big concretions, and by far the greatest number and mass of concretions in general, were in the B_{ir} horizon of the lower profile. Only small, light weight ones, fewer in number, occur in the upper profile. A similar pattern is present in the archaeological pits at SBa-1170 (Tables 4-10), with two exceptions: in Pit 1 the greatest number and collective mass were in the upper levels (Table 4-5), though no concretion longer than 4.8 cm or heavier than 28 gm occurs in the upper 40 cm of the profile. This pattern, though unusual, can be explained by rodent mixing. In pit 2, however, a concretion 8.1 cm in long axis, and one

weighing 66 gm occurred in the upper 40 cm (Table 4-6). This exception can be explained by relatively infrequent large mammal (badgers, coyotes) burrowing activities in the Oceano soils.

While it is concluded that the Oceano and window soils have experienced excessive faunal mixing, the presence of genetic horizons in them (Figure 4-17a, 4-17b; Plate 4-5a, 4-5b) indicate that soil horizonation processes have nevertheless predominated over soil mixing processes in soil formation. They are thus less mixed than the Gopher 1, 2, and 3 soils on the Signorelli Ranch that show little horizonation (Figures 4-18a, 4-18b).

Older Dune and Ancient Dune Soils

Though extremely interesting in their morphology and genesis, due to time constraints and the fact that they have little direct relevance to archaeological studies because of their great age, Older and Ancient dune soils were examined only in reconnaissance fashion for this study. Nevertheless, in terms of their areal extent they are far and away the most predominant soils on Vandenberg. They are the soils that cover South Vandenberg, Burton Mesa, the Casmalia geomorphic surface, and North Mesa (Figure 4-4), where they cover the Qt_4 through the Qt_7 surfaces.

There are three main soil types comprising the Narlon and Tangair Series in the Older and Ancient Dune terrains: the Narlon soils, the Narlon hardpan variant soils, and the Tangair soils. The Narlon Series soils have clayey B horizons; the Tangair Series soils do not, but have iron-cemented and/or silica-cemented B horizons. The Narlon hardpan variant soils have a silica-cemented subsoil pan (durapan). All three soil types commonly have iron-cemented sand concretions in the A and sometimes B horizons. In places, the A horizon of these soils has been re-worked by wind; in such places it may be mapped as Marino sand on the Soil Survey.

Narlon Soils: The Narlon soils are classified as clayey, montmorillonitic, mesic Aeric Ochraquults. In the Soil Survey, they are mapped according to slope as NrB (0 percent to 5 percent), NsA (0 percent to 2 percent), NsC (2 percent to 9 percent), and NsD (9 percent to 15 percent). A typical profile description of the Narlon soils, based on a representative profile, is given in Appendix 4-A (from the Soil Survey, p. 56). The following is a Narlon series description (from the Soil Survey, pp. 55-56).

> The Narlon series consists of moderately well drained soils that have a loamy sand surface layer and a clay subsoil. These soils are underlain by old marine deposits. They are on moderately dissected terraces. Slopes range from 0 to 15 percent. The vegetation is annual grasses, forbs, and low chaparral. Elevations range from 200 feet to 800 feet. The average annual rainfall is 14 to 17 inches, the average annual air temperature is about 55 degrees F., and the frost-free season is about 300 to 320 days. Narlon soils are associated with Tangair soils.

In a representative profile, the surface and sub-surface layers are light brownish-gray, pale-brown, and light-gray loamy sand about 32 inches thick. The subsoil is gray and olive-gray clay and sandy clay that extends to a depth of more than 60 inches. Beneath the subsoil are sandy marine sediments. These sediments normally are underlain by diatomaceous shale. In some areas the texture of the surface layer is sand.

Narlon soils are used mainly for military purposes and for range.

Narlon Soils, Hardpan Variant: The Narlon hardpan variant soils are classified as clayey, montmorillonitic, mesic Aquic Haploxerults. In the Soil Survey they are mapped according to slope as NvA (0-2 percent) and NvC (2-9 percent). A typical profile description of the Narlon hardpan variant soils, based on a representative profile, is given in Appendix A (from the Soil Survey, pp. 57-58). The following is a series description of the Narlon hardpan variant (from the Soil Survey, p. 57).

> The Narlon series, hardpan variant, consists of moderately well drained soils that formed on wind-modified, sandy, old, marine terrace deposits. These soils are on terraces, most extensively in Vandenberg Air Force Base and to a small extent on low benches in the Santa Maria Valley. All areas are within 10 miles of the coast. Slopes are 0 to 9 percent. The vegetation consists of low brush and sparse annual grasses and forbs. Elevations range from 200 to 800 feet. The average annual rainfall is 14 to 17 inches, the average annual air temperature is about 57 degrees F., and the frost-free season is about 300 to 320 days. Narlon soils, hardpan variant, are associated with Narlon and Tangair soils.
>
> In a representative profile, the surface layer is grayish-brown and light-brown sand about 14 inches thick. It is underlain by about 12 inches of pink sand. The subsoil is mottled, mixed dark-brown very dark grayish brown, and yellowish-brown sandy clay about 12 inches thick. Below are partially cemented sandy marine sediments.
>
> These soils are used for range, for military purposes, and for homesites and other nonfarm uses.

Plate 4-2b shows an approximate Narlon soil on the Casmalia geomorphic surface (though mapped in the Soil Survey as Tangair).

Tangair Soils: The Tangair soils are classified as mixed, mesic Typic Psammaquents. In the Soil Survey they are mapped according to slope as TaA (0 percent to 2 percent) and TaC (2 percent to 9 percent). A typical

profile description of the Narlon soils, based on a representative profile, is given in Appendix 4-A (from the Soil Survey, pp. 79-80). The following is a series description of the Tangair soil (from the Soil Survey, p. 79).

> The Tangair series consists of somewhat poorly drained sandy soils that formed in old marine terrace deposits. These soils occur on terraces and in some places are dissected by drainageways and gullies. Tangair soils are almost entirely within the Vandenberg Air Force Base. Slopes are 0 percent to 9 percent. The vegetation is predominantly brush and sparse annual grasses and forbs. Elevations range from 150 feet to 900 feet. The average annual air temperature is about 57 degrees F., and the frost-free season is 300 to 320 days. Tangair soils are associated with Narlon soils.
>
> In representative profile, the surface layer is light-gray sand about 24 inches thick. The subsoil is very pale brown sand that contains iron concretions. It extends to a depth of 48 inches. Below is white sand. All areas are underlain by shale or other very slowly permeable material at a depth of 4 feet to 12 feet. This material is not part of the described soil.
>
> Tangair soils are used for military and other non-farm purposes. An example of a buried approximate Tangair soil is shown in Plate 7.

CONCLUSIONS

Vandenberg Air Force Base has a fascinating array of landscape elements that are either directly relevant to, or provide a background context for, the archaeological studies being conducted. These elements include the bedrock geology, marine and stream terraces, alluvial fans, sand dunes, mound microrelief, and soils. I hope that this study of the landscape elements, especially the sand dunes and soils, has illuminated the possible and probable processes that have blurred or otherwise affected certain aspects of the archaeological record. These aspects include the apparent mixed character of the Oceano (Old dune) and window (Intermediate dune) soils and sediments.

It is concluded that mammal burrowing, principally by pocket gophers and ground squirrels, and to a lesser but still important extent, by badgers, coyotes and other surface digging animals, is and has been an important mixing factor in the Oceano and window (Sk) soils. Such mixing probably began soon after soils began developing upon the Old dunes that overlie the late Pleistoncene stream terraces (Qt_2, Qt_3) in the lower San Antonio Creek area. Soil mixing continued in re-exposed Oceano windows within the Intermediate dunefield after the latter advanced over the Old dune surface.

FUTURE STUDIES

During the course of this project, several areas were identified where continued research efforts should pay important dividends of paleoecological data that would be relevant to archaeological mitigations. I have broken these areas down by subject in outline form below.

Paleoecological and Geochronological Studies	Analytical Technique
Lake at Pt. Sal (above Mussel Rock) (late Pleistocene)	C-14, pollen
MOD Lake (late Holocene)	C-14, pollen
Cul-de-Sac Lake in Juan Pedro Canyon (Holocene)	C-14, pollen
Punch Bowl Lake (late Pleistocene-Holocene)	C-14, pollen
Casmalia caprock locality	Paleomagnetic dates
Qt_4 & Qt_5 and older surfaces on Lospe Mountain	Amino acid dates

Quaternary Geological and Soil Studies	Analytical Technique
Shuman Canyon silcretes (durapans)	Paleopedological analyses
Caprock locality	Paleopedological analyses
Bear Canyon iron-cemented concretions, some of which contain charoal nuclei	C-14
Santa Ynez and San Antonio terraces	C-14, pollen, amino acid dates, paleopedological analyses
Role of ground squirrels in soil formation	Material analyses of ground squirrel spoil piles, and extent and geometry of their burrow systems

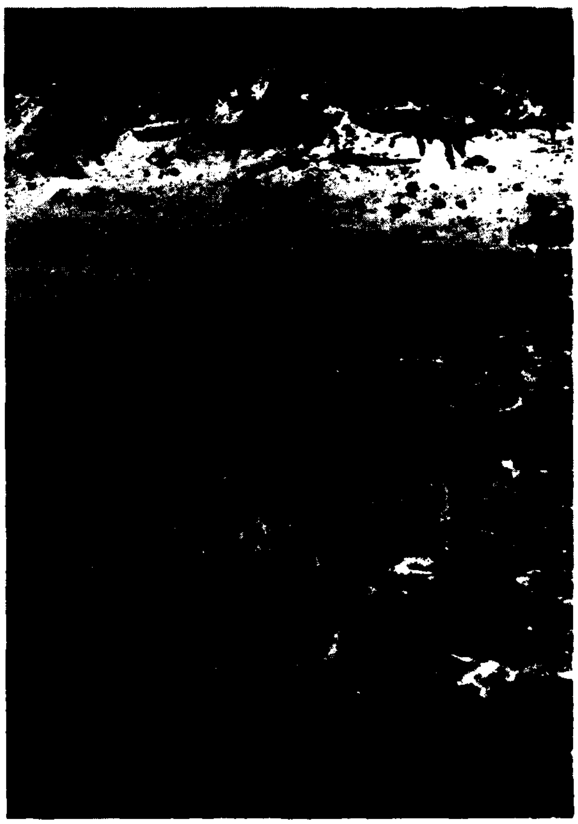


Plate 7. Two views of an approximate Tangair soil in a borrow pit on the northeast side of Hito Road west of its intersection with Cross Road, near and north of the west end of the airstrip. The Tangair soil is shallowly buried here under as much as a meter of wind worked sand. Note person for scale.

would be close to the age of the tree. The wedge yielded excellent tree rings, which showed the tree to be about 100 years old. It germinated in the 1870s or 1880s.

While the tree-ring study was conceived in an air of optimism, it ended with marginal results--one dated tree. The information gained was useful, but probably not commensurate with the effort expended. Nevertheless, the date supports various other lines of independent evidence cited in the text that the Intermediate dunefield is late Holocene in age and largely stabilized within historic or protohistoric time.

Oceano Soils Profile Description

Representative profile of the Oceano series (approximately 4 mi. southeast of Santa Maria, NW 1/4 sec. 36, T10N R34W):

A11--0 to 1 1/2 ins., grayish brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) when moist; single grain, soft, very friable, non-sticky and nonplastic; many very fine roots; many very fine interstitial pores; medium acid (pH 5.8); clear, smooth boundary.

A12--1 1/2 to 4 ins., grayish brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) when moist; massive; soft, very friable, nonsticky and nonplastic; common very fine roots; many very fine roots; many very fine interstitial pores; medium acid (pH 5.6); gradual, smooth boundary.

C2--39 to 55 ins., pale-brown (10YR 6/3) sand, yellowish brown (10YR 5/4) when moist; massive; soft, very friable, nonsticky and non-plastic; very few micro roots; many very fine interstitial pores; several weak Liesegang bands 1/8 in. thick (7.5YR 4/4m, 5/4d), slightly hard, somewhat branched, upper band bends up into C1 horizon; slightly more firm and more harsh than C1 horizon; very strongly acid (pH 5.0); gradual, smooth boundary.

C3--55 to 72 ins., light yellowish-brown (10YR 6/4) sand yellowish brown (10YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; no roots; many very fine interstitial pores; Liesegang bands 1/4 inch thick, hard when dry; two continuous bands, several discontinous, similar in color to band in C2 horizon; black manganese specks 1 to 5 mm in diameter make up about 1 percent of mass; strongly acid (pH 5.1); gradual, smooth boundarv.

C4--72 to 90 inches, light yellowish-brown (10YR 6/4) sand, yellowish brown (10YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; many very fine interstitial pores; weak bands 1/4 inch to 3/8 inch thick, discontinous, slightly wavy, sand grains very thinly coated; sand slightly coarser than in C3 horizon; strongly acid (pH 5.5).

The horizon ranges from sand to loamy sand in texture and from grayish brown and light brownish gray to pale brown in color. In some places a few brown to dark-brown bands of iron or clay, about 1/8 in. thick, are within 2 ft. of the surface. Reaction ranges from very strongly acid to medium acid.

Narlon Soils Profile Description

Representative profile of the Narlon series (on Vandenberg Air Force Base, 0.9 mile west of 13th Street on New Mexico Street, 270 ft. south of railroad track):

A11--0 to 2 ins., light brownish-gray (10YR 6/2) loamy sand, dark grayish brown (10YR 4/2) when moist; weak, coarse, platy structure; slightly hard, very friable, nonsticky and nonplastic; many very fine roots; many very fine interstitial pores; medium and acid (pH 6.0); clear, smooth boundary.

A123--2 to 15 ins., pale-brown (10YR 6/3) loamy sand, brown (10YR 4/3) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; common very fine roots, abundant roots in a few soil joints; many very fine interstitial pores and few very fine tubular pores; strongly acid (pH 5.3); small reddish-brown sandy iron concretions, 1/8 to 1/4 in. in diameter, make up 2 percent of soil mass; gradual, wavy boundary.

A21--15 to 23 ins. light gray (10YR 7/2) loamy sand, yellowish brown (10YR) 5/4 when moist, many, medium, faint mottles of pale brown (10YR 6/3); massive; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores, common very fine and few fine tubular pores; strongly acid (pH 5.3); small reddish and larger yellowish concretions, 1/8 inch to 2 inches across, make up 8 percent of soil mass; gradual, smooth boundary.

A22--23 to 32 ins., light-gray (10YR 7/2) light loamy sand, brown (10TR 5/3) when moist; massive; slightly hard, very friable, nonsticky and nonplastic; few very fine roots; many very fine interstitial pores and few very fine tubular pores; strongly acid (pH 5.5); clear, wavy boundary.

AB--32 to 35 ins., 40 percent of soil mass is brown (10YR 4/3m) sandy clay loam that has continuous, moderately thick clay films in bridges; has relic-rounded column tops and irregular lumps of degrading material from B2 horizon 1/4 in. to 2 ins. in diameters; remaining 60 percent of soil mass is light-gray to white (10YR 7/2, 8/1d) loamy sand that has weak, skeletal column tops and very few thin clay bridges in some places.

B21t--35 to 50 inches, gray (5Y 5/1) clay, dark gray (5Y 4/1) with dark reddish brown to strong-brown and light olive-brown (2.5YR 3/4, 3/6, 7.5YR 5/6, 2.5 5/4) mottles when moist, dark yellowish brown (10YR 4/4) mixed when rubbed; many, medium, prominent, yellowish-red to reddish-yellow (5YR 5/6, 3/6, 4/4, and 7.5YR 6/6) mottles; moderate, coarse, columnar structure; very hard, extremely firm, very sticky and very plastic; few very fine roots on exterior of peds, very few very fine tubular pores; continuous moderately thick clay films on ped faces, clay nearly fills all pores; some clay films on ped faces are dusky-red (10YR 3/2); very strongly acid (pH 5.0); few random, distinct slickensides; diffuse, smooth boundary.

B22t--50 to 67 ins., olive gray (5Y 5/2) sandy clay, mottled as in B21t horizon but olive hues more dominant; moderate, coarse, prismatic structure; very hard, extremely firm, very sticky and very plastic; very few very fine roots on ped faces; clay films and reaction same as in B21t horizon; very few irregularly shaped pockets and joints filled with white sand similar to A2 horizon, pockets and joints have very abrupt boundaries; few random distinct slickensides.

Round chert and quartzite gravel is scattered through the A horizon of this profile and makes up less than 1 percent of that horizon. A few fragments of siliceous shale are scattered through all horizons and make up about 1 percent of the total volume.

Color of the A1 horizon ranges from light brownish-gray to gray or pale brown. Texture ranges from sand to light sandy loam. Thickness of the A1 horizon, in some places, ranges from 14 to 20 ins., and the thickness of the A2 horizon ranges from 6 to 36 ins. Thickness, texture, and color of the A1 horizon depends partly on the mild "hog-wallow" relief and other microswale features. The A1 horizon is darker, finer textured, and thicker in the swales and is lighter, coarser textured, and thinner on the knolls. The A2 horizon is thickest in the higher area. Depth to the B21 horizon ranges from about 20 to about 50 ins. Where depth to the B2t horizon is greatest and the subsoil is less clayey, the Narlon soils grade into the Tangair soils. Narlon soils are underlain by siliceous shale at depths of 48 to more than 60 ins.

Narlon Soils, Hardpan Variant Profile Description

Representative profile of the Narlon series, hardpan variant (approximately 3 mi. north of Lompoc, about 120 ft. south and 360 ft. east of the intersection of Burton Mesa Road and Highway No. 1):

Ap--0 to 7 ins., grayish-brown (10YR 5/2) sand, dark grayish brown (10YR 4/2) when moist; massive; soft, very friable, nonsticky and nonplastic; many micro, very fine, fine and medium roots; many very fine interstitial pores and common very fine, fine and medium tubular pores; few hard concretions about 1/4 in. across have a black center and dark reddish-brown outer shell; medium acid (pH 6.0); abrupt, smooth boundary.

A1--7 to 14 ins., light-brown (7.5YR 6/4) sand, brown (7.5YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; few very fine and common medium roots; many very fine interstitial pores and many very fine, fine and medium tubular pores; concretions similar to those in the Ap horizon but slightly more numerous and large; medium acid (pH 6.0); gradual, irregular boundary.

A2--14 to 26 ins, pink (7.5YR 7/4) sand, brown (7.5YR 5/4) when moist; massive; soft, very friable, nonsticky and nonplastic; few very fine roots and fine and common medium roots; many very fine interstitial pores and many very fine, fine and medium tubular pores; soil mass is 1 to 2 percent concretions similar to those in the Ap horizon except that they are 1/4 in. to 1 1/3 ins. across; medium acid (pH 6.0); abrupt, wavy boundary.

B21t--26 to 30 ins., prominently mottled and mixed dark-brown to yellowish-brown (10YR 4/4, 4/3, 3/3, 5/4) light sandy clay, with seams of light gray (10YR 7/2, 7/3), very dark grayish brown to dark yellowishbrown (10YR 3/3, 3/2, 4/4) when moist; strong, medium and coarse, columnar structure; very hard, firm, sticky and plastic; few very fine, fine and medium roots; many micro and very fine interstitial pores and many very fine tubular pores; common moderately thick and thick clay films lining tubular and interstitial pores, and common films on ped faces; column tops are strongly leached for 1/4 to 1/2 in., and nearly all clay films are gone from the leached portion; tongues of A2 horizon material extend irregularly several ins. into some joints; strongly acid (pH 5.5); gradual, wavy boundary.

B22t--30 to 38 ins., prominently mottled and mixed yellowish-brown to very dark grayish brown (10YR 5/6, 5/4, 4/3, 3/2) light sandy clay, about the same colors when moist; strong, medium and coarse, prismatic structure; very hard, firm, very sticky and very plastic; few very fine, fine, and medium roots; few micro interstitial pores and very fine tubular pores; continuous thick clay films in pores, and continuous moderately thick clay films on ped faces; continuous, nearly black wavy bands about 1/8 in. thick; very strongly acid (pH 5.0); gradual, irregular boundary.

C1si--38 to 46 ins., dark-brown (10YR 4/3) weakly cemented loamy and dark brown (10YR 3/3) mottled with yellowish brown and very dark brown (10YR 5/4 and 2/2) when moist; many large, distinct, pale-brown and brownish-yellow (10YR 6/3 and 6/6) mottles; massive; very hard, firm, brittle, nonsticky and nonplastic; few very fine and fine roots; many very fine interstitial pores; many thin clay bridges holding mineral grains together, common moderately thick clay films in old tubular pores; soil is weakly cemented and panlike; very hard silica-cemented cap, 1 to 3 mm thick, on top of pan; very strongly acid (pH 5.0); gradual, irregular boundary.

C2si--46 to 72 ins., yellowish-brown (10YR 5/6), weakly cemented light loamy sand; many medium, light brownish-gray and dark yellowishbrown (10YR 6/2, 4/4) prominent mottles, mottles grayish brown (10YR 5/2, 4/4, 4/2) when moist; massive; hard, firm, brittle, nonsticky and nonplastic; no roots; many very fine interstitial pores; many thin clay bridges between mineral grains. common moderately thick clay films filing old tubular pores; weakly cemented; strongly acid (pH 5.5).

Tangair Series Profile Description

Representative profiles of the Tangair series (Vandenberg Air Force Base, Surf quadrangle, 120 degrees 34' 10" W., and 34 degrees 44' 50" N.; 1/4 mile west of Missile Control Center, about 75 yards north of road):

- A1--0 to 4 ins., light-gray (10YR 6/1) sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry or moist, nonsticky and nonplastic; common very fine and few fine roots; many very fine interstitial pores; medium acid (pH 6.0); clear, wavy boundary.

A2--4 to 24 ins., light-gray (10YR 7/2d and 10YR 7/2m) sand; single grain; loose when dry or moist, nonsticky and nonplastic; few fine and very few medium roots; many fine interstitial pores; incipient reddish brown (5YR 5/4 to 6/4m) concretions 1/16 to 1/8 in. across make up less than 0.5 percent of mass and are uniformly distributed; slightly acid (pH 6.4); gradual, wavy boundary.

B21ir--24 to 36 ins., very pale brown (10YR 7/3), sand, light gray (10YR 7/2) when moist; single grain; loose when dry or moist, nonsticky and nonplastic; very few fine roots; many very fine interstitial pores, concretions similar to those in A2 horizon make up 5 to 15 percent of mass and tend to occur in pockets 1 to 2 ft. across; strongly acid (pH 5.3); gradual, smooth boundary.

B22ir--36 to 48 ins., very pale brown (10YR 7/3) sand, light gray (10YR7/2) when moist; single grain; loose when dry or moist, nonsticky and nonplastic; very few fine roots in upper part; many very fine nterstitial pores; concretions make up 15 to 35 percent of horizon and occur mostly in pockets several feet across; concretions range in size from 1/2 in. across to as large as 3 by 6 ins., and are reddish brown in color (5YR 3/4, 4/4, 5/4m and 10YR 5/4 to 5YR 4/4d); shell of concretions is redder than the interior; small concretions and interior of larger ones have higher chromas and are softer; concretions are very hard when dry; strongly acid (pH 5.5); gradual, wavy boundary.

C--48 to 56 ins., white (10YR 8/2) sand, light gray (10YR 7/2) when moist; single grain, loose, nonsticky and nonplastic; no roots; many very fine interstitial pores; very few soft concretions similar to those in B21 and B22 horizons; strongly acid (pH 5.4).

The A1 horizon, or the darker parts of it, is generally 3 to 6 ins. thick in a few places. Color of the A1 horizon is light brownish gray to gray and light gray. Texture of the A1 horizon is sand or loamy sand. A few small concretions are present in some places, but are more common on sloping areas that are somewhat eroded and dissected. The A2 horizon is white or light gray and in most places has a few small iron concretions. The A2 horizon grades into the B2ir horizon, which contains a larger number of concretions, and these two horizons are separated on the amount of concretions. Concretions commonly make up about 30 percent of the B2ir horizon, but the amount ranges in some places from about 15 to 20 percent to nearly continuous sheet of connected concretions that form an irregular hardpan 6 to 20 ins. thick.

All areas are underlain by shale or other very slowly permeable material at a depth of 6 to 12 ft. This material is not part of the solum. Reaction is very strongly acid to slightly acid throughout the profile.

In mapping, Tangair soils were separated from Narlon soils on the basis of lacking a clayey Bt horizon above 48 to 60 ins. in depth. Thus, some areas are mapped as Tangair soil that might be classed as a very deep surface phase of Narlon soil. Tangair soils normally have enough concretions to have a gravelly, very gravelly, or impenetrable pan-like feel when augured.

Chapter 5

WIND DISPLACEMENT OF ARCHAEOLOGICAL MATERIALS

INTRODUCTION

This section describes preliminary studies of the rates at which the wind alters archaeological deposits on the San Antonio Terrace. The San Antonio Terrace is partially overlain by active dunes believed to be less than 7,000 years old (Cooper 1967; see also Chapter 4). Ninety-seven archaeological sites have been recorded on the terrace and most of these are situated in the modern or intermediate dunes (see Chapter 4). Of these 97, 54 are in the project area (and are considered in Chapter 3). The remainder are in other locations on the terrace and are given some consideration in this analysis because of their relevance to understanding the processess of wind displacement of site constitutents.

Large quantities of sand and artifacts are moved by the almost constant and often forceful northwesterly winds. On windy days, for example, the surface of the dunes is blurred by a layer of saltating sand grains and the dunes seem to smoke as sand is blown from their crests. At these times, archaeological survey and excavation crews often needed to wear goggles as protection against flying sand, and small lithic flakes were sometimes seen flipping along the surface. Archaeological studies in the active regions of the terrace should be undertaken with the understanding that at least some of its sites have been altered extensively by the wind.

INTERVENING FACTORS

The measurement of changes in the landscape on the terrace is complicated by more than two centuries of modifications by non-indigenous peoples. Direct modifications have included grazing, intentional vegetation, construction and military manuevers. Modifications have been caused indirectly by pumping the ground water (lowering the water table) and by damming the rivers to the north (reducing the sand supply). Other factors with longer term implications include natural fluctuations in the water table and the occurence of fire.

The following sections consider these intervening factors in order. The magnitudes of their respective influences are discussed but are not quantified with certainty.

Grazing

The grazing of sheep and cattle on the terrace may have had an accelerating effect on dune advance through the removal of vegetation. Grazing by sheep is reported by Roberts (Appendix II) and Johnson (Chapter 4 and personal communication) to have occured during the first half of this century but the number of animals involved has not been quantified. Cattle have grazed on the terrace during the latter half of the ninteenth century and the first half of this century . The finding of occasional cattle bones in the central dunes and the appearance on the 1928 aerial photos of a relatively denuded area between a fence line 6 km inland and the Southern Pacific Railroad Tracks are further evidence of grazing.

Intentional Stabilization by Vegetation

One of the most striking differences between the 1928 and 1978 photos is the disappearance of large areas of open sand. Almost 30 percent of the areas open at the turn of the century are now anchored by exotic vegetation. This is almost certainly due to the intentional stabilization of these areas (H and J, Figure 5-1) by the Southern Pacific Railroad and local ranchers. Exotic plants (*Ammophila arenaria*, *Pinus* sp. and *Acacia* sp.) were planted to anchor the sands to prevent them overrunning the tracks.

The area bounded by the dotted line (Area A, Figure 5-1) is a vegetated zone which appears to have been planted just prior to the taking of the earlier photos. On the ground examination of this area reveals the same community of exotic plants and the steep slopes characteristic of the other recently vegetated areas.

The open dunes in the north-central terrace (Dune K and several others not illustrated in Figure 5-1) have also been intentionally revegetated by ranchers at Marshallia Ranch for unknown reasons. The area of open sand in Dune K has been diminished by half since 1928 while the other open areas north and east of Dune K have been completely vegetated during that time. The overall effect of intentional vegetation has been a great reduction in the amount of sand moved by the wind per unit of time.

Fluctuations in the Water Table

The water table on the central terrace is not constant nor should it be considered a single entity. Water stands at at least six different elevations from 25 to 250 feet. These and the exposed Pre-Flandrian surfaces (Cooper 1967) are evidence of the presence of obscured marine terraces which have created a stepped-perched water table.

Reference stakes placed in 13 wetlands indicate seasonal variation in the height of the inland water tables while those lowest (and nearest the coast) remain relatively stable. What seems to be happening is that during the winter rains the perched water tables are charged. With a diminution of rainfall in late spring, summer, and fall the water perched on the higher terraces runs off to the next lower until one by one from highest to lowest the water tables are lowered and the wetlands dried. The dry season is not currently long enough to permit the drying of those wetlands nearest the coast.

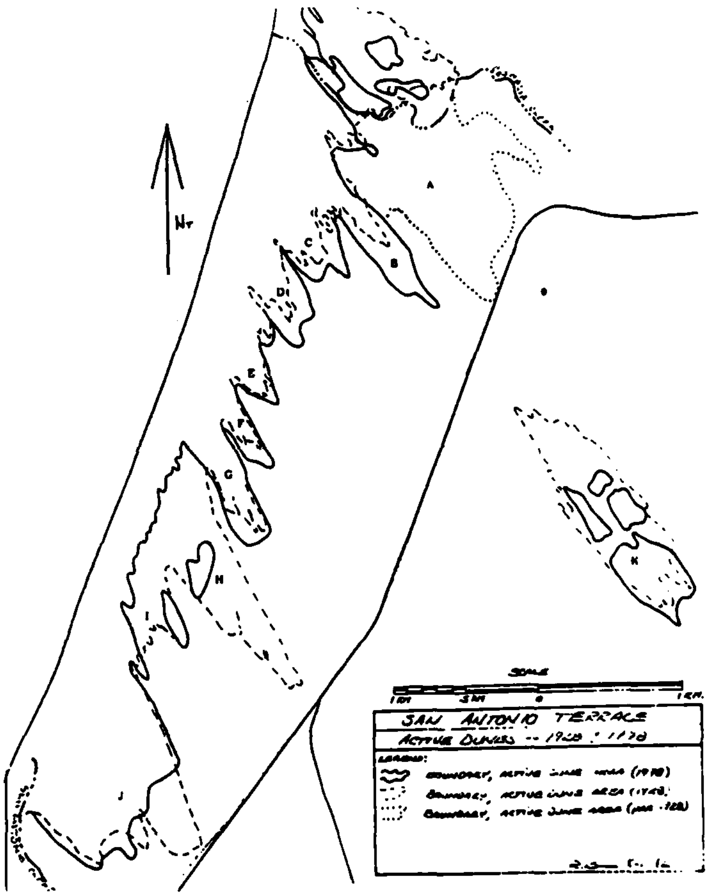


Figure 5-1. San Antonio Terrace Active Dunes.

During the winter and into the fall, fresh water appears just seaward of the foredunes and runs across the beach to the sea. This water is probably forced to the surface by the rim of the lowest buried terrace. When the available water from the more highly perched tables diminishes to the point that no more is being supplied to the table nearest the beach, the spring dries. At the onset of the winter rains the flow begins anew.

Reduction of the Sand Supply

Some of the sand transported by the longshore current is derived from the erosion of the shore cliffs north of the terrace (Cooper 1967) and this source of sand has remained relatively constant through the historic period. An undetermined portion of the sand moved south by the longshore current is supplied by the transport of sediments to the sea by rivers. Historic damming of the Santa Maria River at Twitchell reservoir and other drainages north of the study area has substantially diminished the riversupplied sand to the south-flowing longshore current and subsequently to the beaches. This reduction in the sand supply has slowed the rate of dune advance (Envicom 1980a, 1980b) with the result that recent measurements of dune movement probably reflect rates slower than those in the prehistoric past.

Fire

The removal of vegetation by fires accelerates the rate of sand movement in the affected area(s). The presence of people living and cooking at a location may increase the likelihood of fires downwind, and the arrival of prehistoric peoples on the terrace (especially at the upwind extremities) may have resulted in an increase in the occurance of wild fires and an increase in the rate of dune movement. This is suggested by the presence at various locations of a thin strata of charcoal flecks overlain by several meters of sand. The charcoal was probably generated in a wild fire upwind, blown across the surface and then covered by the sands freed by the burning of the stabilizing vegetation. The overlying sand often contains windblown flakes.

BACKGROUND DISCUSSION

Sources of Sand

Sand brought to the coast by rivers and eroded from shore cliffs is carried south by the longshore current and deposited on the beach. From there the northwest winds drive it southeast and inland. Of the winds with velocities greater than 10 knots, 80 percent blow from the northwest (U.S. Air Force Air Weather Service 1967-1978). Additional sand is added to the volume of moving sand as vegetated areas are smothered by overriding dunes and then deflated. Also, dunes may have existed west of the present shoreline when the sea level was lower and, if so, a considerable body of sand may have been pushed ahead of the advancing shoreline and may have

contributed to the present active dune system. I believe (but cannot demonstrate) that the older underlying sands are the result of the shore-line advance and that the present modern and intermediate active dunes are a much more recent occurrence.

Duneform

The bulk of the sand within 750 m of the coast has been blown into transverse ridges, a characteristic of areas with "unlimited" sand supply "unlimited" area, and steady winds (Melton 1940; Cooper 1967). Transverse dunes are oriented at 90 degree angles to the wind and resemble ocean waves. Vegetation capped shrub-coppice dunes also occur in the coastal zone, being concentrated within 500 m of the strand.

On aerial photographs and maps, the central dunes appear to stream across the landscape from the northwest in long coalescing parabolic ridges open to windward. These are the "elongate parabolic" dunes discussed by Melton (1940) and Cooper (1967), and are characteristic of areas with "strong winds of constant direction" and impeding vegetation.

EFFECTS OF WIND AND OTHER FORCES

As noted above,the study of natural changes in the landscape of the San Antonio Terrace is complicated by more than two centuries of modification of the area by non-indigenous peoples. Direct modifications have included grazing, intentional vegetation, construction and military manuevers. Modifications have been caused indirectly by pumping the ground water and by damming the rivers to the north. Nevertheless, it is possible to measure the effects of the wind and other forces on the area and to suggest the implications of these effects on archaeological site interpretation. These effects include the burying of deposits, the deflation of deposits, the merging of deposits, artifact sorting, artifact alteration, and the creation and extinction of wetlands. The discussion which follows will treat each of these effects in turn.

Burying of Deposits

Only the grains being blown along the upper surface, those airborne as they are hurled off the crest, and grains falling to the base down the slip-face are being moved by the wind at any one time. That is, the dune tends to move like the tread on a tank or bulldozer with the base remaining stationary on the "surface," the top moving forward and the front falling on whatever happens to be in its path (Bagnold 1941). If the "whatever" happens to be an archaeological site then the site is neatly buried by the leading (depositional) edge of the dune.

Deflation of Deposits

Deflation of site deposits occurs when the lighter fraction of the deposits is removed by the wind, leaving behind the heavier fraction. The site deposits become much shallower in the process; in fact, some may end up with no depth at all. As a dune moves, the lighter material (sand, small lithics, shell, bone and other organics) at the trailing (erosional) edge are lifted and moved across the surface of the dune. The softer materials are weathered away both mechanically (by sand abrasion) and chemically. A thoroughly deflated archaeological site contains only those items resistant to wind transport and to chemical attack, usually large pieces of chert, fire affected rock and grinding and hammer stones. These are termed "lag" deposits.

Merging of Deposits

Discrete archaeological deposits may be merged by the wind in three important ways. First, as one deposit is being deflated at the upwind (erosional) edged of an advancing dune, the items susceptable to aeolian transport may be deflated and blown across the surface to fall down the slip-face on another deposit. If the recipient deposit has not yet been deflated, this process will result in the formation of a "site" with an upper stratum containing an unusually high percentage of small flakes, some of which display the polish and edgewear characteristic of wind transport. If the downwind deposit has been previously deflated, the proportions of lithic flakes of various sizes in the resultant deposit may resemble those in an undisturbed site, since the recipient site would gain some of the same classes of materials it had lost to prior deflation. Still, the smaller flakes will display the unmistakable traces of transport (polish and edge rounding) and the larger pieces will be sandpolished. There will also be a conspicuous lack of organics.

Second, two or more stratified cultural deposits may be merged. As an upper stratum is deflated, its lighter fraction is blown away while its heavier lag materials "fall" onto the underlying deposits. Both strata may be eventually deflated leaving an assemblage of lag artifacts from different depositional episodes in a single stratum which may be lower than either of the original deposits. If the lower deposit has not been deflated, a deposit will form containing an upper "lag stratum" of large, sandpolished artifacts.

Third, small dunes travel faster than large (Melton 1940), and if each contains windblown flakes, the flakes carried by a small windward dune will merge with those in a larger lee dune as the small dune catches up with the larger. The resulting deposit will contain small mechanically weathered flakes from several deflationary episodes at the same site or from several different sites.

Artifact Sorting

Initial sorting of artifacts by the wind (see Deflation of Deposits above) includes the separation of the light fraction of a deposit from the lag materials. The presence of dense clusters of well-sorted windblown flakes at SBa-1193 and -1201 suggests that further sorting occurs subsequent to the initial deflation of a deposit. On the surface of site SBa-1201, several such clusters were seen in actual transport by the wind. Some of these contain only very small flakes, few being larger than .5 cm in length. Others contain larger flakes, ranging in size from 1 to 3 cm. Still others are made up of intermediate-sized flakes (.5 cm to 1 cm) with very few large or small flakes. This fine sorting is probably the result of winds of different speeds lifting flakes of different sizes, and/or aerodynamic characteristics.

Artifact Alteration

The alteration of artifacts occurs as they are impacted by saltating sand grains or as the artifacts themselves are lifted by the wind and fall back to the surface. The former process is responsible for the high polish seen on the large lithics in well-deflated deposits. If polish is present it usually occurs on all surfaces of even very large artifacts, suggesting that they are reoriented (rolled) as the sand on which they rest is undercut by the wind.

Smaller pieces, i.e., those small enough to be transported by the wind, are also polished. However, since a blowing flake is much more massive than a grain of sand its return to the surface likely results in a much more damaging collision than the impact of a sand grain on its surface. Since the chances are small of an airborn flake falling absolutely flat, the force of most of its landings is absorbed by an edge. Small flakes therefore are not only polished by the wind, their edges are also disproportionally abraded. The relationship between the amount of edge wear and the distance a flake has been blown is discussed below, under Measurement of Artifact Displacements.

Creation and Extinction of Wetlands

Both aerial photos and on-the-ground examination demonstrate that wetlands come and go, as do the surrounding dunes in which they are formed. Factors which influence the creation and extinction of wetlands include fluctuations in the water table(s), movement of sand and the presence of subsurface features.

The dynamic nature of the wetlands is stressed here because it has been suggested that the aboriginal inhabitants may have concentrated their activities near wetlands. This may indeed be true, but the present proximity of sites to wetlands is not proof enough. Admittedly, there is a good chance of finding intact deposits near wetlands, but wetlands are so numerous that no site on the terrace is very far from a wetland. Sites laid down on older (Pleistocene) surfaces and then buried may have remained buried. Prior to their burial, such sites may have been at the surface long enough for soil development to have made them resistant to deflation. If such sites exist, they are likely to appear in low areas near wetlands, the wind having exposed both the site and the water table.

Other Factors

Though they are not the primary focus of this study, forces other than the wind have altered the cultural deposits on the terrace and should be discussed briefly. These include bioturbation and rainfall.

Bioturbation: Bioturbation is everywhere in evidence, the result of excavations by insects (primarily crickets), small mammals (moles and squirrels) and larger mammals (badgers and coyotes). In some areas fresh tailings from these excavations are so numerous that the overall effect of bioturbation may be a thorough mixing of the sands within a meter of the current surface. Archaeological sites with intact stratigraphy are probably, for this reason alone, rare in the modern and intermediate dunes.

Rainfall: Rainfall moves sand from dune crest to trough. During and after significant rainfall small alluvial fans several meters wide can be seen at the base of water channels cut into the dunes' slopes by the flow of rainwater. No doubt artifacts as well as sand are transported by the rain from high point to low. The overall effect of rainfall is a levelling of dunal relief and a general lowering of artifacts' elevations.

Summary

The above discussions present a general description of the San Antonio Terrace and of the effects of the wind on the overlying sands and archaeological deposits; a description of the methods employed to measure these effects and a presentation of the findings follows.

THE MEASUREMENT OF SAND DISPLACEMENT

Methods

Sand displacement was measured by two methods: remote and direct. Remotely sensed data included aerial photographs taken by Fairchild in 1928 and 1938 and those taken in 1972 and 1978 by the U.S. Air Force. Direct measurements of sand movement were made at reference stakes placed in the dunes.

Measurements from Aerial Photographs: The comparison of aerial photographs taken in the 1920s and 1930s with those taken more recently allows the rough calculation of rates of dune movement for the last 50 years. Using the Southern Pacific Railroad tracks and the shore line as reference points, the distances traveled by various masses of sand have been determined.

Figure 5-1 is a map produced by tracing the boundaries of the open sand areas (Johnson's "Modern" Dunes) from the Fairchild photos of 1928 (dashed line). The positions of the areas of open sand in 1978 (solid line) were then plotted from LANDSAT photos provided by the environmental office at Vandenberg Air Force Base. Areas on the map are lettered for ease of reference in the text.

As was discussed above, intentional vegetation has made the projection of recent measurements into the prehistoric past difficult. For this reason, dune advance rates were calculated by measuring only dune segments which have not been affected by intentional vegetation. The areas useful in this regard are the dune segments labeled B, C, D, E, F, and G in Figure 5-1.

A study corridor has been outlined (Figure 5-2) which parallels the alignment of the dunes and the prevailing winds, and which ranges from the north edge of Dune Segment B to the south edge of Dune Segment G. The corridor's length averages 7 km (max. = 9, min. = 5) and its surface area is 14.5 k^2. Included within this corridor are the areas from which the dune segments being measured were blown and the areas to which the segments will be blown. The study corridor, by including only those areas from which the dune segments being measured have been and will be blown, allows the calculation of the length of time necessary for the volume of sand now overlying the corridor to have accumulated.

Three measures were calculated using aerial photographs: linear advance, areal advance, and volumetric accumulation. The draft of Figure 5-1 was drawn on graph paper from data derived from the 1928 Fairchild aerial photos and 1978 Air Force aerials. Linear advance was determined by measuring the distance between the points of each dune segment farthest inland in 1928 and in 1978. Area figures were derived by counting the squares enclosed in the areas buried since 1928.

The volumetric data were derived by first plotting three profiles of the terrace. Two profiles represent cross-sections of lines parellel to the prevailing northwest winds and extended between the beach and the southeasternmost extention of the recent dune sheet. The other profile extends from the northern edge of the terrace southwest to San Antonio Creek.

Once the profiles were drawn, the locations at which older soils are exposed were marked on them and a line drawn between these represents the estimated position of the lower extent of the recent sands. The average thickness of the dune sheet was then determined by measuring (at 70 equidistant locations) the distance between the older surface and the present surface and computing their mean. The average thickness was multiplied by the area of the dune to derive the total volume.

Reference Stakes: One hundred one 4 feet long wood lath stakes were placed in the dunes to provide reference points for the measurement of vertical and horizontal sand movement. A line was drawn one-third of the way up each stake; the stake was then driven to that line. The amount of sand accumulation or deflation at a stake was measured from this line.

Thirty-three stakes were systematically spaced on two lines (A and B) extending 134 degrees (true) inland from the edge of the strand. The remainder of the stakes was placed in groups to focus the measurements on specific landforms on the central terrace. Figure 5-3 illustrates the placement of the stake lines and groups.

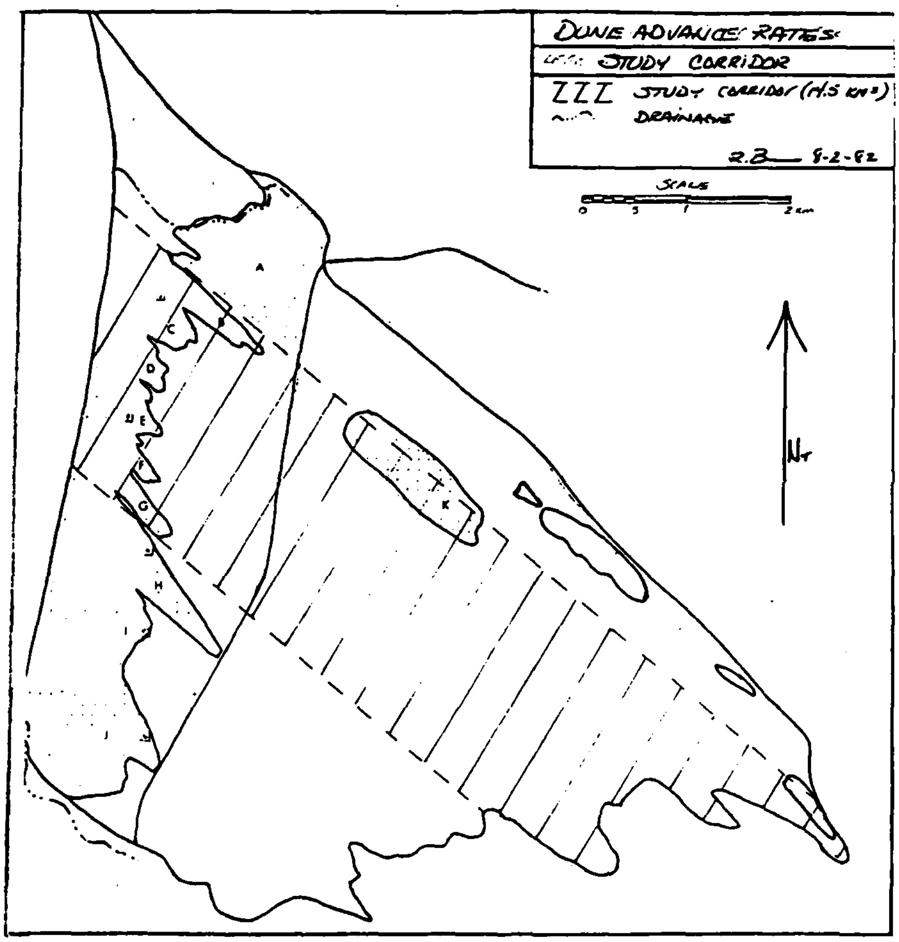


Figure 5-2. Dune Advance Rates Study Corridor.

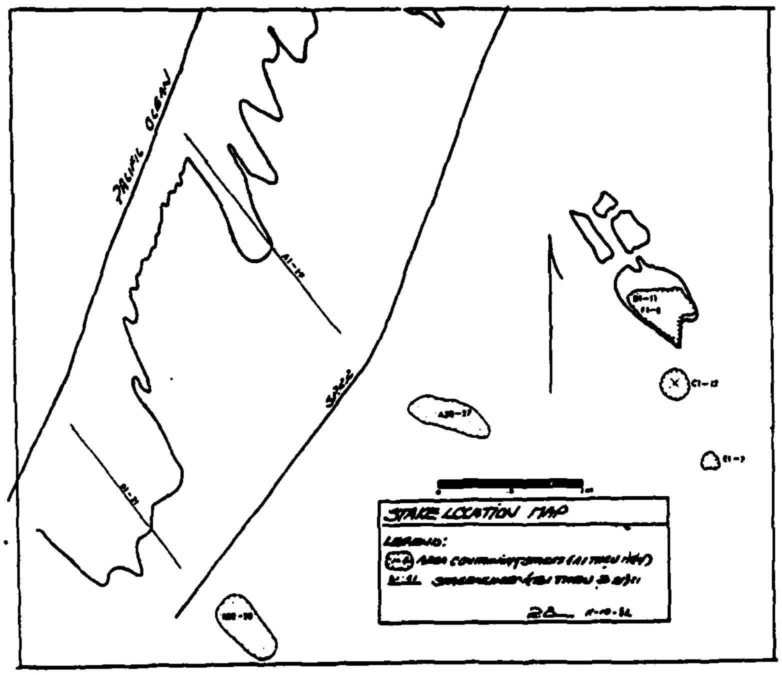


Figure 5-3. Stake Location Map.

Table 5-1. Stake Data.

STAKE DATA

	STAKE	MEASUREMENTS IN CM. UP OR DOWN OCT	NOV	DEC	MAY	TOT	SLOPE	WIND EXPOS.	LAND FORM	DISTANCE INLAND	VEG	
A	1	-3		1	0	1	0	0	4	.1	1	0
	2	0		0	-1	1	0	0	4	.2	1	0
	3	1		16	27	27	62	9	3	.3	1	1
	4	0		-4	1	9	0	0	4	.4	1	0
	5	0		-1	-1.5	1.5	0	0	6	.5	0	0
	6	-1.5		0	-5	5	5	0	6	.6	0	0
	7	1		.5	-2	3	5	0	6	.7	0	0
	8	1		.5	1	1	5	0	6	.8	0	0
	9	-3.2		-2.5	-30	30	15	0	6	.9	0	0
	10	-3		-4	-22	22	25	6	5	1	0	1
	11	-1		-2.5	-12	12	26	6	5	1.1	1	1
	12	-3.7		-5.5	-5	6	25	5	4	1.2	1	0
	13	3.4		2	.5	3.5	0	0	1	1.3	1	0
	14	2						0	1	1.3	1	0
	15	-1		-1	-1.	1	18	0	6	1.5	1	0
	16	0		0	2	2	16	5	5	1.6	1	0
	17	0		-1	-2	2	22	1	5	1.7	1	0
	18	-3		-2.5	-4.5	4.5	14	1	5	1.8	1	0
	19	-.3		-1.5	-3	3	0	0	4	2	1	0
	20			-2	-4	4	0	0	4	2.4	1	0
	21			0	-.3	.3	19	3	5	2.55	1	0
	22			-1	-1.5	1.5	21	4	5	2.65	1	0
	23			-1	-.6	1.6	26	4	5	2.75	1	0
	24			0	0	0	10	3	4	2.8	1	0
	25			0	-1	1	3	7	5	2.8	1	0
	26			-2	-3	3	20	0	5	2.88	1	0
	27			0	-2	2	0	0	4	3	1	0
B	1			7	2.5	11.5	5	0	4	.09	1	1
	2			0	5	5	15	0	4	.14	1	0
	3			2	0.5	0.5	0	0	4	.19	1	0
	4			0	2	2	0	0	6	.24	0	0
	5			0	0	0	42	1	5	.29	1	0
	6			2	2.5	2.5	40	0	5	.34	1	0
	7			0	0	0	0	0	6	.39	1	0
	8			0	0	0	12	3	6	.44	1	0
	9			-2.5	-2	3	2	0	6	.49	0	0
	10			-2.5	-2.5	2.5	5	0	4	.54	0	0
	11			0	0	0	4	0	4	.59	0	0
	12			-5	-15	15	6	0	6	.64	0	1
	13			-4	-2.5	5.5	20	0	4	.69	1	0
	14			0	13	13	60	0	4	.74	0	1
	15			-2	-2	2	12	7	5	.79	0	0
	16			2.5	0	2.5	70	0	6	.84	0	0
	17			2	19	19	62	0	1	.86	1	1
	18			0	-2	2	12	0	4	1.05	1	0
	19			2.5	-2.5	5	17	7	5	1.15	0	0
	20			3.5	1	6	21	9	5	1.25	1	0
	21			0			5	0	4	1.36	1	0
	22			0			2	0	4	1.0	1	0
	23			1	0	2	0	0	4	1.8	1	0
	24						0	9	6	1.65	1	0
	25			0	.5	.5	0	0	6	1.95	1	0
	26			0	0	0	0	0	4	2	1	0
	27			0	0	0	0	9	6	2.1	1	0
	28			-1.3	0	1.3	0	0	6	2.1		0
C	1			-1	0	1	12	3	5	4	1	
	2			0	0	0	10	3	5	4	1	
	3			0	0	0	0	3	5	4	1	
	4			0	-3	3	12	5	5	4	1	
	5			1	2	2	27	5	5	4	1	
	6			1	3	3	7	5	5	4	1	
	7			0	1	1.	7	7	5	4	1	
	8			0	-1	1	6	7	5	4	1	
	9			-1	0	2	9	7	3	4	1	
	10			-2	-.5	3.5	12	1	5	4	1	
	11			-1	-.5	1.5	11	1	5	4	1	
	12			-1	-1	1	9	1	5	4	1	
	13			-3	-4	4	2	0	4	4	1	
D	1		-2	-3	-10	10	4	0	6	3.5	0	
	2		-2.5	-2	-12	12	4	0	6	3.5	0	
	3		-2.5	1	-5	7	4	0	6	3.5	0	
	4		-3	-2.5	-1.5	3.5	4	0	6	3.5	0	
	5		15.5		10	10	40	0	1	3.5	0	
	6		2		0	0	59	9	3	3.5	0	
	7		0		21	21	20	0	1	3.5	0	
	8		3.5		5	5	0	9	3	3.5	0	
	9			-3	-10	10	42	0	1	3.5	0	
	10			0	4	4	62	4	2	3.5	0	
	11			1	1	1	62	4	3	3.5	1	
F	1				-32	32	19	0	6	3.4	0	
	2			1.5	27	27	42	0	1	3.6	0	
	3			10	50	50	62	4	3	3.6	1	
	4			0	-0	0	5	0	6	3.6	1	
	5			3.5	9	9	34	0	1	3.6	0	
	6			19	30	30	34	4	3	3.6	1	
	7				15	15	63	4	6	3.6	1	
	8			-4	-25	25	62	4	6	3.6	0	

AVERAGES

GROUP	OCT	NOV	DEC	MAY	TOT	SLOPE	N
A	-.605		-.40	-2.3	3.77	12.96	
B			.194	1.02	4.35	15	
C			-.54	-.31	1.77	10.15	
D		1.30	-1.2	1.60	9.05	29.18	
F			6.33	10.0	27	42.63	
AVERAGE	-.605	1.30	.059	2.17	9.19	21.90	
OPEN DUNES					11.7	26.40	
VEG. AREAS					3.95	9.680	

The Stake Data Table (Table 5-1) is a presentation of the measurements taken from the stakes. Stakes were set in late September 1981, and measurements were made in October, November, and December 1981, and again in May 1982. Negative numbers indicate deflation (the distance in centimeters down the stake to the surface of the sand). The TOT column presents the total amount of movement (deflation and deposition) calculated from measurements made in December and May only.

Findings

Dune Advance: In the case of linear advance the average of the segments studied was 210 m in 50 years or 7,000 m (the average length of the corridor) in 1667 years. These linear rates are comparable to estimates presented in the study of the Mussel Rock Unit of the Nipomo Dunes (Envicom 1980a).

Table 5-2. Dune Advancement Rates
Measured Between 1928 and 1978

Dune	Linear Movement (Meters)	Rate Per 100 Years	Area Covered (m^2)
B	550	1,100	145,000
C	210	420	80,000
D	190	380	102,500
E	100	200	20,000
F	160	320	45,000
G	50	100	47,500
Total	1,260	2,520	440,000
Mean	210	420	

Measurements were also made of the linear advance of the recently vegetated inland dune labeled K in Figure 5-1. This dune is moving more slowly than the coastal dunes because its sand supply is anchored by vegetation. Half its surface area has become anchored by exotic plants in the last 50 years yet its leading edge advanced 150 m during that time, yielding a rate of 300 m per century. Dunes moving at this diminished rate require 2,333 years to traverse the dunefield.

Approximately 440,000 m^2 were buried under new sand in the corridor in the past 50 years. At that rate it would take 1,648 years for the entire 14.7 k^2 study corridor to be covered. In other words, at present rates, 1 km^2 is covered in the corridor every 113 years, 1 km^2 is buried over the entire terrace (30.6 km^2) every 53.55 years.

The average thickness of recently deposited sand over the entire terrace (and within the study corridor) is 4.74 m, yielding a volume of 69,678,000 m^3 in the study corridor. The average thickness of the recent portions of dune segments B through G was determined both cartographically and by triangulation in the field; it is 4.4 m. These have a total volume of 1,801,250 m. By dividing the total volume of new sand in segments B through G and multiplying by the 50 years between 1928 and 1978, a figure of 1,934 years is derived. This is the time required for the accumulation of the volume of sand overlying the corridor at recent rates of deposition.

Open vs. Vegetated Areas: The most notable contrast on the terrace is that between the open (modern) and vegetated (intermediate) dunes. The terms "active" and "stable" have been applied to these two areas respectively. Stake measurements indicate, however, that though the areas are characterized by different rates of sand movement, both areas are quite active. Stakes A1 through A14, B1 tnrough B17, D1 through D11 and F1 through F8 (see Appendix) placed in open dunes, while A15 through A27, B18 through B28, and C1 through C13 were placed in vegetated areas. The average displacement measured in the open dunes was 11.7 cm compared with 1.95 cm in the vegetated areas.

Open areas now occur both along the coast and at one location in the central terrace. The single open area in the central terrace (Dune K) is being vegetated rapidly from its windward end by introduced grasses. Its leeward end is a large open area displaying a morphology typical of the more inland of the open coastal dunes.

As would be expected, the area of Dune K being vegetated displays characteristics transitional between open dunes and the more vegetated areas. This is a zone in which relief is still quite high. Indeed, dunes in the process of being vegetated seem to develop unusually high slip-faces, as sand movement down on the semi-vegetated slip faces is considerably slowed (compare stakes D5 through D11 with F2 and F6). Longitudinal ridges, typical of vegetated areas, are beginning to form where sand falls, and seedlings take root in the low velocity zones alee of plants.

Vegetated areas are more extensive now than in the recent past. In 1850, Dune K was the southeastern end of an expanse of open sand, which extended from the beach (Johnson, Chapter 4 and personal communication). Area A (Figures 5-1 and 5-2) was probably open sand at that time, and dune segments H and J were more extensive. All of this vegetative increase is associated with the planting of exotic plants, primarily the introduced marram grass (*Ammophila arenaria*). No intact archaeological deposits have been found in areas in which these grasses predominate, suggesting further that the sands on which they grow are recently deposited.

Slope: Steep slopes are a characteristic of open dunes. The average slope recorded in the open (modern) dunes was 26.4 percent compared to 9.69 percent in the vegetated (intermediate) areas. Only one measured vegetated slope (C5; 27 percent) exceeded the average open slope. This reduction of grade is primarily the result of the downslope transportation of

sand by rainwater (Cooper 1967). Wind also has a levelling effect as it blows sand from the crests of vegetated dunes into the swales where vegetation slows the wind to velocities below those necessary to lift the sand again.

Wetland Recurrence: Comparisons of aerial photographs taken in 1928 with those of more recent origin reveal that some wetlands seen in the earlier photos no longer exist. Also wetlands now exist in areas where only open sand can be seen in the earlier photos.

In several places wetlands are being filled at their windward ends by advancing dunes. Near the beach in the open dunes this process is quite a rapid one. Dune Segment G, for example (see Figure 5-1), has advanced at least 50 m in the last 50 years, covering 47,500 m^2 of wetland in the process. The rates of wetland burial in the more vegetated dunes are much slower.

Subsurface features such as buried drainages, hilltops, or marine terraces influence whether water will occur at the surface. The likelihood of a wetland occuring at a spot where sands have buried a small knoll is smaller than over a buried drainage, or where a terrace perches water high enough to be exposed in adjacent blowouts.

At several locations in SBa-721, recent winds have exposed stratified extinct wetland deposits; one is 50 cm above the other and the lower is a meter above the surface of an adjacent, extant wetland. The extant wetland does not appear on the 1928 Fairchild aerial photos and the wetland therefore must be less than 50 years old. Radiocarbon (mrt) dates from the two stratified deposits are "recent" (300 years), suggesting a fluctuating water table and periodic wetland recurrence in that location. The radiocarbon dates suggest a life expectancy of less than 125 years for near-coastal wetlands.

A mat of decaying organic material is built up over time in the bottoms of wetlands. Examination of the thickness of the organic mats in "new" wetlands (those which have appeared since the taking of the 1928 Fairchild aerial photographs) revealed organic mats 1 to 2 cm thick, suggesting a mat development rate of 2 to 4 cm per century.

The rate of organic mat development varies between wetlands. The water table in the central dunes subsides in the summer and fall to the extent that many wetlands dry completely for six months each year and others display a significant reduction in the amount of area covered by water. This is not true in the coastal zone, where the water table remains quite stable. Organic mats may not grow in thickness when the wetland is dry. If not, a probable result is that the organic mat development in the central dunes occurs at approximately half the rate seen in the coastal zone or 1 to 2 cm per century. Only one wetland examined in the recent coastal or inland dunes had developed an organic mat thicker than 4 cm (10 cm) and most were less than 2 cm thick. The average age of wetlands in the central dunes is thus likely to be less than 200 years, while the oldest is probably less than 500 years old.

Bass Lake: Bass Lake (also referred to as MOD Lake) was formed as an advancing dune blocked an unnamed drainage near its discharge into the San Antonio Creek basin. The 2 to 3 cm of organic mat in Bass Lake suggests

that the drainage was blocked less than 200 years ago. Since the blockage, substantial archaeological deposits (SBa-980 and -981, which are actually loci of a larger continuous archaeological deposit) have been laid down on the blocking sands. These deposits are of great value because they are so obviously recent and uncontaminated by older materials. The chronological placement of other sites on the terrace and in the region may be facilitated by comparison with materials (not yet collected) from SBa-980 and -981.

The blockage of the Bass Lake drainage happened after the sands responsible passed through the area recorded as archaeological site SBa-1193. At the average rates of linear advance calculated above, SBa-1193 was overriden by a substantial body of sand less than 300 years prior to the blockage of the drainage, or less than 500 years ago. The ability to date these episodes and the presence of a wide variety of resources makes the area between Bass Lake and the coast a valuable study area.

THE MEASUREMENT OF ARTIFACT DISPLACEMENT

Methods

The discovery of sites on the San Antonio Terrace that consist entirely of windblown chert flakes (SBa-1193, -1201, the latter outside the project area) and that contain windblown flakes as a component (SBa-581, -1170, -1173, -1176, -1179, -1682) suggested caution in the interpretation of artifact distributions and functions. The great number of windblown flakes and their wide distribution on the terrace demanded that an attempt be made to demonstrate the ability of the wind to move artifacts and to determine the magnitude of their actual displacement. Even at sites with demonstrably intact deposits (e.g., SBa-1179) can contain small flakes blown in from upwind locations (see Analysis of Chipped Stone Artifacts, Chapter 9).

Artifact displacement was measured in two ways: by the placement and observation of experimental artifact scatters and by the measurement of edge attrition to flakes caused by wind transport. In order to measure how the wind moves chipped stone artifacts, two deposits of flaked glass were placed on the surface in the open Dune K. Colored glass flakes were used to prevent any subsequent confusion between the experimental flakes and those laid down by prehistoric peoples. (Both the flaking characteristics of glass and its specific density are close enough to those of the local chert that the results of the experiments may be taken as close approximations of the displacement of prehistoric materials.)

Flakes were produced by hard (basalt) and soft (antler and bone) hammer and by pressure flaking with antler from large blocks of colored glass. The flakes were then screen-sorted into four size categories: small (1/16 to 1/8 inch), medium (1/8 to 1/4 inch), large (1/4 to 1/2 inch) and massive (larger than 1/2 inch). These were counted and laid down at the points of origin of the experimental scatters.

Scatter No. 1 was a deposition of 7,827 flakes at the apex of a pie-shaped collection area pointed into the prevailing northwest winds (see Figure 5-4). Twenty-five 1 m squares of 1/16 inch mesh screen were buried at selected spots within the collection area to serve as the collection units. They were to be lifted at the termination of the experiment and the number of flakes found of each size in each screen recorded. It was hoped that enough flakes would be collected by this mothod to allow the determination of differential rates of movement for flakes of various sizes. The wind, however, quickly uncovered and undercut many of the collection screens, forcing a change in collection strategy.

"Flake traps" were then devised which would catch flakes blown into them. These were 50 cm wide screen fences fabricated from 1/16 inch mesh window screen and set perpendicular to the wind. Each was fabricated from a square of screen by folding, and held in place by a stake. Unfortunately, 1/16 mesh screen clogs when rain or dew moistens the sand and a small sand hill formed at the location of each trap. (This clogging also occurs in 1/8 inch screen traps, while 1/4 inch and larger meshes work quite well.) Both the collection screens and the traps were removed from the collection area.

The collection technique finally adopted involved shovelling six shovels full of sand from each collection point into 1/16 inch screen and the retrieval of flakes from the screen. Flakes were collected after six months, bagged in the field, and size-sorted and counted in the lab. The results are presented in Table 5-2.

Scatter No. 2 involved a circular collection area 6 m in diameter, bounded by a 1/16 inch screen fence and centered on the point of origin. It was the intention to collect flakes at frequent intervals from regularly spaced points just inside the fence. The hope was that the circularity and the short distance from the point of origin to the point of collection (3 m) would allow not only the measurement of differential flake movements by size but that the direction of displacement could also be measured. Again, the small screen size resulted in a ring-shaped mound of sand around point of origin. A collection was made from Scatter No. 2 one month after its placement and just prior to the removal of the screen fence. The results of the collections are presented in Table 5-3.

Edge Attrition: Several lines of evidence pointed northwest to the near-coastal zone as the source of the secondarily deposited flakes. These were:

- The presence of a likely source of the windblown flakes in the almost continuous deposit of lag materials between the mouth of Shuman Canyon to the mouth of San Antonio Creek;

- The lack of likely source sites elsewhere on the terrace;

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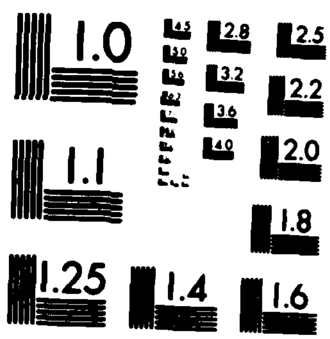

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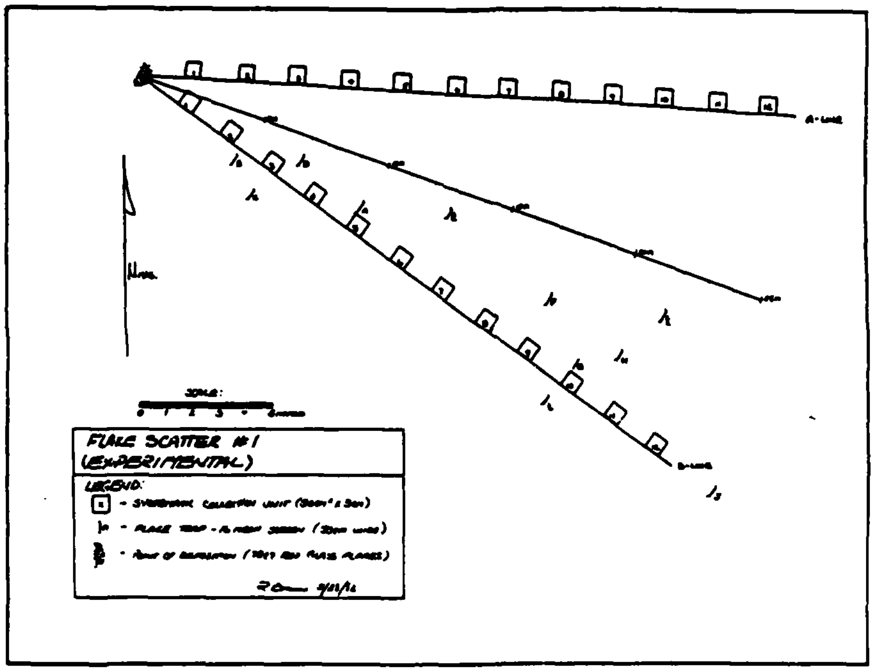

Figure 5-4. Experimental Flake Scatter No. 1.

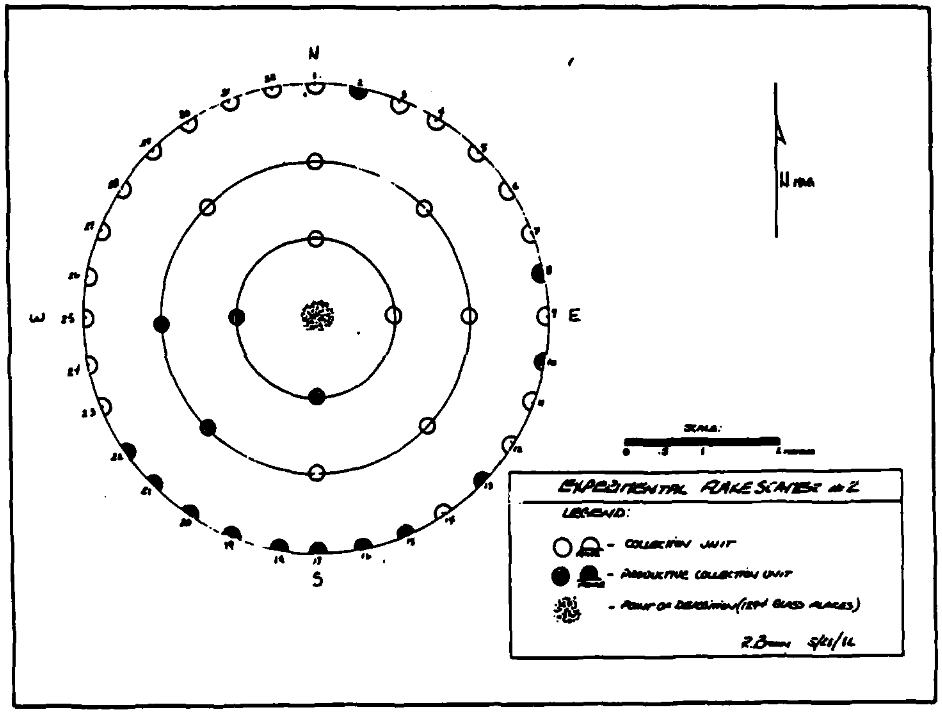

Figure 5-5. Experimental Flake Scatter No. 2.

Table 5-2. Experimental Flake Scatter No. 1.

EXPERIMENTAL FLAKE SCATTER # 1

FLAKE SIZE COUNTS:

		IN	OUT	% OUT
SMALL	1/16-1/8	6246	726	11.66
MEDIUM	1/8-1/4	1175	595	50.64
LARGE	1/4-1/2	318	253	79.56
MASSIVE	)1/2	88	77	87.50
TOTAL		7827	1653	21.12

DISTANCES MEASURED FROM POINT OF ORIGINAL DEPOSITION

SMALL FLAKES

DISTANCE (IN METERS)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
A LINE	8		3		2				1										1							15
B LINE	26		10		2		2		3								1									44
TRAPS			6	15		22			4			7					13		3	4	13				1	88
TOTALS	34	0	19	15	4	22	2	0	8	0	0	7	0	0	0	0	14	0	4	4	13	0	0	0	1	147

MEDIUM FLAKES

DISTANCE (IN METERS)

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
A LINE	5		1																							6
B LINE	0		2		1																		1			12
TRAPS				2					1			1					1		2	1	1				1	10
	13	0	3	2	1	0	0	0	1	0	0	1	0	0	0	0	1	0	2	1	1	0	1	0	1	18

NOTE: The only "large" flake was found in TRAP J (26 meters out).

Table 5-3. Experimental Flake Scatter No. 2.

EXPERIMENTAL FLAKE SCATTER #2
(A circular area-6m in diameter-bounded by a window screen fence)

FLAKE SIZE COUNTS:		IN	OUT	% OUT
SMALL	1/16-1/8	800	33	04.13
MEDIUM	1/8-1/4	357	128	35.85
LARGE	1/4-1/2	99	92	92.93
MASSIVE	>1/2	38	27	71.05
TOTAL		1294	280	21.64

Scatter was divided into 32 segments, the first oriented toward magnetic North.
Distances measured from point of original deposition at center of circle.

	N							E									S								W									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	TOT	PERCENT
1 METER																																		
SMALL																	1								1								2	66.66667
MEDIUM																	1																1	33.33333
LARGE																																	0	0
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3	100
PERCENT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	0	0	0	0	0	0	0	33	0	0	0	0	0	0	0		
2 METERS																																		
SMALL																									1								1	50
MEDIUM																					1												1	50
LARGE																																	0	0
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	100
PERCENT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	50	0	0	0	0	0	0	0		
3 METERS																																		
SMALL										3						1	3	57	11	14		1											90	67.66917
MEDIUM	1							1		1					2	3	13	16	2	2	2												43	32.33083
LARGE																																	0	0
TOTALS	1	0	0	0	0	0	0	1	0	4	0	0	0	0	2	4	16	73	13	16	2	1	0	0	0	0	0	0	0	0	0	0	133	100
PERCENT	.8	0	0	0	0	0	0	.8	0	3.	0	0	0	0	2.	3.	12	55	10	12	2.	.8	0	0	0	0	0	0	0	0	0	0		

- Weather data which suggest long-term and powerful northwesterly winds over the terrace; and

- The alignment of the dunes themselves, which suggests movement from the coast toward the southeast

But the above constitute only circumstantial evidence. A measure of displacement that would allow the determination of the distance an assemblage of windblown flakes had been displaced was needed.

It seemed likely that the farther an assemblage of flakes is blown across the sand the greater is the damage its edges will sustain. It was decided to measure the attrition to the edges of flakes from the various windblown assemblages. If the source sites were coastal, then this measurement should vary directly with the actual distance between the assemblage and the coastal zone.

Microscopic examination of freshly manufactured chert flakes and of unused prehistoric flakes from non-dune contexts reveals that their sides converge in cross section to a precise point. It is this characteristic of chert which makes it so useful a material in cutting tools. It is this characteristic also which allows (by providing a reference point) the measurement of the amount of material which has been removed by sand blasting and during wind transport.

The amount of edge wear seen on even the most worn of flakes is small (usually less than 1 mm of edge retreat). The accurate measurement of such small amounts of wear was accomplished as follows:

1. Flakes from each "assemblage" were collected from points equidistant from the shore line. Four of the six assemblages were gathered from individual loci.

2. Suitable flakes were between 1/4 inch and 1/2 inch long and had at least one convex edge with an angle of less than 40 degrees.

3. Each flake was examined under a four power magnifier and its sharpest edge was selected for measurement. Stepped, hinged, broken or chipped edges were rejected. Only one measurement was taken from any single flake.

4. An impression of the selected edge was made in a small wedge of modelling clay. This impression was then backlighted and photographed through a microscope using Ilford HP-5 film. A comparator reticle bearing a scale calibrated in tenths of millimeters and including a 90 degree protractor was also photographed at the same magnification. The film was commercially processed to 3 x 5 prints resulting in 153X enlargement of the edge impressions and reticle.

5. A copy of the reticle was traced on clear acetate film, then used as an overlay to measure the angle of the edge's impression and the distance back from the projected apex of the measured angle that the edge had been eroded.

This procedure resulted in the recording of the distance between a flake's original edge (assuming that the flake was once sharp) and its present (eroded) edge. But linear edge retreat ("b" in Figure 5-6) is not a good measure of edge attrition. Thin flakes with very acute edge angles tend to wear back more quickly since a given amount of edge retreat requires, on them, the removal of less material than on flakes with less acute angles. Therefore the area of the triangle, constituting the missing edge material (in profile) was calculated using the formula .5b x h. This area figure was used as the measure of edge attrition. A total of 144 flakes was thus measured (Table 5-4).

Findings

Although all the objectives of the experimental scatters were not achieved, several phenomena were observed which deserve comment. Six months after the scatters were laid down, all the flakes remaining at the points of origin were collected and the percentages of flakes of the various size categories were calculated. The similarities between the figures from each scatter (see Tables 5-3 and 5-4) and their overall magnitude is striking.

The edge attrition data are presented in Table 5-4. The amount of edge attrition varies directly with an assemblage's distance from the beach. It seems that the farther inland windblown flakes are found, the farther they have been blown. The data strongly suggest the coastal zone as the source of most of the wind-blown deposits.

These data do not, however, support the conclusion that these are assemblages of flakes which were all derived from near-shore sites. For example, scatter diagrams plotting edge retreat vs. edge angle illustrate, as expected, an increasing amount of edge attrition with increasing distance from the shore. However, an increase in the range of measurements can also be seen. This increase in range may be the result of differential weathering. Though all the measured flakes were of Monterey chert and were more or less the same size, some were much more massive than others. More massive flakes may loose their edges more rapidly. Unfortunately the flakes were not weighed as they were measured.

The range increase might also indicate that assemblages collected farther inland include flakes from more than one source site. The farther an assemblage has been blown, the more ground it has traversed and the higher are the chances that it will include flakes from more than one site. (The merging of deposits was discussed above.) The deletion of the highest and lowest measurements from each assemblage sharply reduces the range.

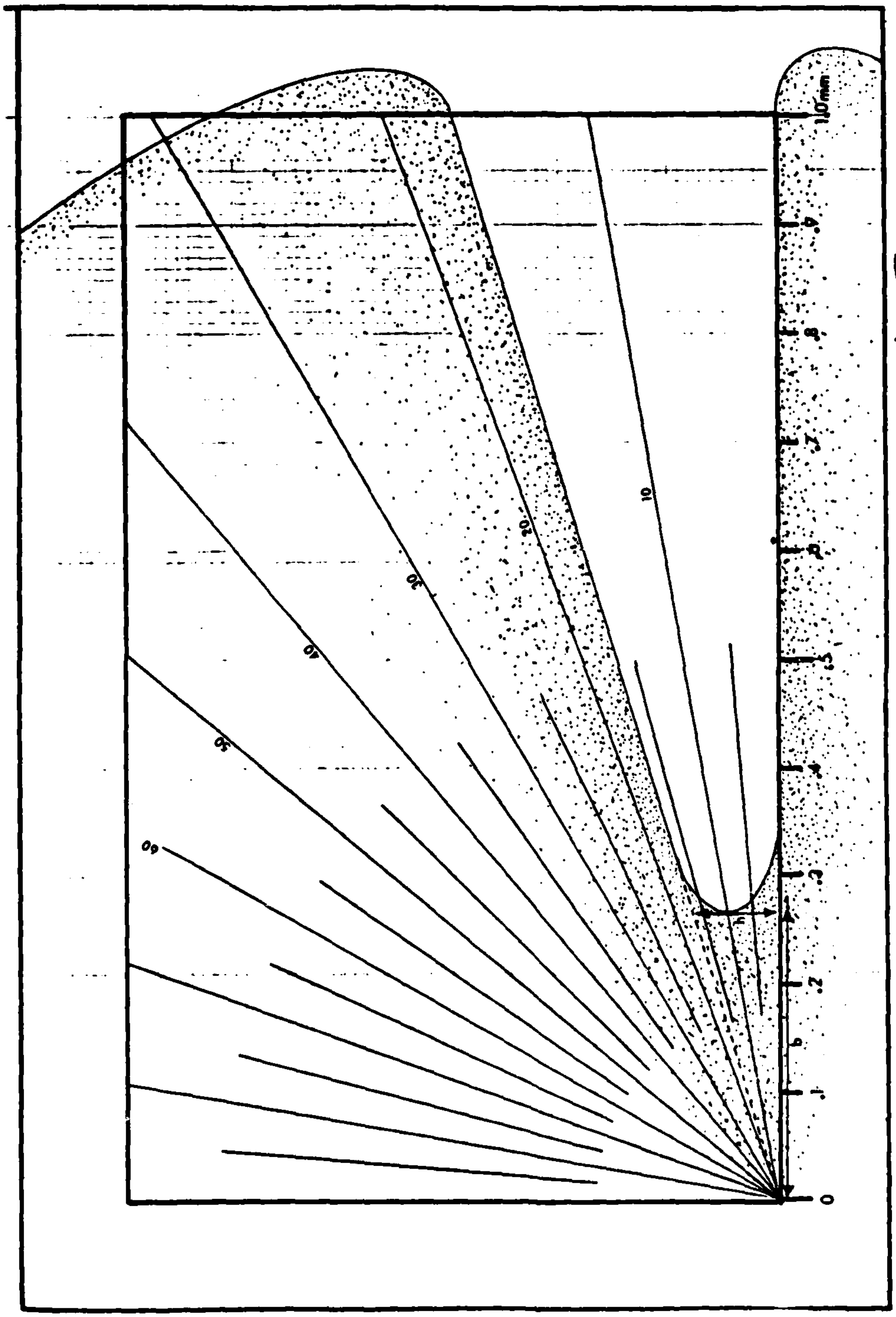

Figure 5-6. Edge Attrition Measurement.

SUMMARY

This study was undertaken in an attempt to measure the effects of the wind on the dunes of the San Antonio Terrace and on the archaeological deposits which they bear. Measurements were made of several indicators of the wind's effects including:

- The movement of large bodies of sand as shown in aerial photographs.
- Deposition and deflation of sand at reference stake locations.
- The deflation of experimental flake scatters.
- Formal changes to wind-transported artifacts.

General Considerations

The data analyzed in this study suggest that dunes are traversing the San Antonio terrace very rapidly. Measurements made at reference stakes show that sand is being displaced very rapidly in the open dune areas and that even vegetated dunes are active. Calculations of present rates made from aerial photographs indicate average linear advance rates of 420 m per century for open dune segments and the burying of a square kilometer under new sand every 54 years. The recent intentional vegetation of open areas and diminution of the supply of sand to the longshore current suggest that the present rates may indeed be slower than those in the prehistoric past.

Radiometeric dating (C-14) of stratified wetland deposits suggests that three separate wetlands occurred at the same location (SBa-721) within the last 300 years. The measurement of organic mat development in extant wetlands indicates a wetland life-expectancy of less than 150 years.

The observation of the deflationary effects of the wind on experimental scatters of glass flakes demonstrates that lithic materials are displaced very quickly. In six months 78 percent of the flakes were removed from each of two separate experimental scatters. The experimental materials which remained at the point of original deposition resembled in size distributions the "lag" deposits so typical of the near-coastal sites. When screening the sands surrounding the experimental scatters in a search for displaced glass flakes, those recovered resembled in size and shape those of prehistoric origin, some of which were found often in the same screen-load.

Measurement of the amount of material abraded from the edges of flakes demonstrates a direct relationship between the amount of edge attrition and the distance the flakes were found from the coastal zone. Though the range of variation of measurements from each assemblage suggests that some of the flakes may have been added to the assemblages from more inland deposits, the data strongly suggest the near coastal zone as the source of the majority of the windblown materials.

Table 5-4. Edge Attrition Data Tables.

EDGE ATTRITION DATA TABLES

"E.R." = EDGE RETREAT "E.A." = EDGE ANGLE "HGHT" = THICKNESS OF FLAKE AT EDGE

	.3 KM INLAND				.5 KM INLAND				1.5 KM INLAND			
N	E.R.	E.A.	HGHT	AREA	E.R.	E.A.	HGHT	AREA	E.R.	E.A.	HGHT.	AREA
1	.1	20	.04	.002	.1	15	.03	.0015	.25	24	.12	.015
2	.1	25	.05	.0025	.35	17	.108	.0189	.6	10	.105	.0315
3	.1	15	.03	.0015	.2	20	.074	.0074	.3	18	.078	.0078
4	.12	25	.06	.0036	.18	20	.097	.0087	.4	16	.115	.023
5	.1	15	.03	.0015	.5	18	.09	.0225	.12	10	.04	.0024
6	.2	15	.055	.0055	.4	18	.071	.0142	.3	12	.045	.0045
7	.15	22	.068	.0051	.21	20	.08	.0084	.5	12	.105	.0263
8	.11	34	.077	.0042	.3	15	.084	.0126	.15	15	.04	.003
9	.3	20	.11	.0165	.2	18	.038	.0038	.3	22	.08	.008
10	.19	35	.138	.0131	.22	25	.106	.0117	.28	20	.1	.014
11	.2	30	.12	.012	.23	15	.064	.0074	.45	18	.08	.018
12	.15	20	.058	.0044	.05	40	.061	.0015	.2	13	.05	.005
13	.15	20	.058	.0044	.45	19	.155	.0349	.75	13	.18	.0675
14	.1	30	.061	.0031	.15	25	.07	.0053	.2	20	.072	.0072
15	.05	30	.032	.0008	.32	13	.075	.012	.18	30	.107	.0096
16	.125	21	.05	.0031	.05	30	.035	.0009	.25	13	.06	.0075
17	.15	15	.045	.0034	.2	21	.08	.008	.25	21	.1	.0125
18	.28	15	.077	.0108	.095	40	.08	.0038	.1	30	.06	.003
19	.28	20	.122	.0171	.08	20	.03	.0012	.15	20	.058	.0044
20	.07	30	.044	.0015	.23	18	.075	.0086	.45	10	.08	.018
21					.11	20	.04	.0022	.2	25	.095	.0095
22					.15	31	.092	.0069	.04	30	.03	.0006
23					.15	30	.088	.0066	.2	20	.072	.0072
24					.08	30	.049	.0020	.8	10	.14	.056
25									.2	15	.06	.006
26												
27												
28												
29												
30												
31												
	.1513	23.05	.0663	.0058	.2085	21.75	.0738	.0080	.2720	17.96	.0829	.0147

	4 KM INLAND				4.5 KM INLAND				5 KM INLAND			
N	E.R.	E.A.	HGHT	AREA	E.R.	EA	HGHT	AREA	E.R.	EA	HGHT	AREA
1	.32	20	.119	.0190	.29	15	.08	.0116	.45	20	.168	.0378
2	.69	15	.19	.0656	.55	11	.12	.033	.16	23	.075	.006
3	.3	25	.142	.0213	.4	18	.073	.0146	.7	15	.19	.0665
4	.65	20	.24	.078	.85	18	.15	.0638	.85	9	.135	.0574
5	.35	14	.09	.0158	.29	17	.09	.0131	.5	25	.238	.0595
6	.6	10	.108	.0324	.62	18	.111	.0344	.4	18	.134	.0268
7	.6	5	.055	.0165	1	18	.02	.01	.3	15	.083	.0125
8	.35	10	.062	.0109	.36	18	.065	.0117	.8	15	.22	.088
9	.55	15	.15	.0413	.3	15	.083	.0125	.4	15	.165	.0495
10	.35	15	.15	.0263	.90	18	.175	.0850	.6	15	.165	.0495
11	.3	20	.11	.0165	.7	13	.19	.0665	.8	10	.14	.056
12	.35	10	.115	.0201	.5	15	.135	.0338	.25	35	.18	.0225
13	.73	9	.115	.0420	.57	30	.101	.0288	1	15	.27	.135
14	.37	11	.077	.0142	1.4	10	.25	.175	.5	15	.135	.0338
15	.25	26	.124	.0155	.9	11	.175	.0788	.5	12	.111	.0278
16	.21	30	.120	.0126	.44	14	.11	.0242	.4	15	.11	.022
17	.45	15	.124	.0279	.9	13	.21	.0945	.75	10	.134	.0503
18	.41	15	.11	.0226	1.1	11	.21	.1155	.9	10	.16	.072
19	.35	15	.097	.0170	.65	7.5	.083	.0270	.8	10	.14	.056
20	.54	11	.109	.0294	.3	20	.112	.0168	.6	12	.135	.0405
21	.73	10	.13	.0475	.7	13	.168	.0588	.57	14	.145	.0413
22	.325	10	.06	.0098	.21	22	.09	.0095				
23	.4	15	.11	.022	.26	25	.125	.0163				
24	.325	17	.1	.0163	.28	15	.078	.0109				
25	.35	20	.13	.0228	.45	15	.122	.0275				
26	.65	15	.178	.0579	.5	20	.182	.0455				
27	.3	20	.11	.0165								
28	.2	20	.074	.0074								
	.4206	15.93	.1108	.0266	.5962	13.63	.1272	.0431	.5919	15.62	.1540	.0401

SUMMARY OF MEANS
EDGE ATTRITION TABLE

DIST	E.R.	E.A.	AREA
.3	.1513	23.05	.0058
.5	.2085	21.75	.0080
1.5	.2720	17.96	.0147
4	.4206	15.93	.0266
4.5	.5962	13.63	.0431
5	.5919	15.62	.0401
2.6	.3702	17.99	.0245

The study of the displacement of archaeological deposits has contributed to an understanding of dune/wetland dynamics. The demonstration of the rapidity with which experimental deposits were altered and the great distances traversed by windblown materials have added substance to arguments for the youth and instability of the dunes.

The overall picture drawn from these studies is that the San Antonio Terrace Dunes are young and very dynamic. Archaeological studies focused on terrace sites must take into account the influence which the wind may have had on the form and distribution of archaeological materials.

Site Specific Implications

The following discussion considers the implications of dune movement for the interpretation of sites in the San Antonio Terrace Dunes. The selection of sites for this discussion was based on apparent similarity of the sites' constituents and depositional contexts. This selection was, however, based on data from limited testing and mitigation programs focused in well-defined impact corridors in not-so-well-defined site areas. Four categories of sites will be discussed:

1. Intact Deposits (SBa-1179, -980 through -984, -998, -1070, -1729)

2. Lag Deposits (SBa-226, -713 through -721, -1683, -1684)

3. Windblown Deposits (SBa-1193, -1201)

4. Complex Deposits (SBa-581, -1155, -1682, -1728, -1730)

Intact Deposits: Intact deposits are those which do not appear to have been disturbed by the wind. The artifacts themselves show little formal evidence of either transport or *in situ* abrasion. Intact assemblages do not display disproportionate percentages of lag materials. The presence of a wide range of artifact sizes in dark, organic sand at SBa-1179, and portions of SBa-706 and -998 argues strongly for the undisturbed nature of these deposits. Other apparently intact sites (SBA-980 through -984, -1070, -1729) do not possess darkened soils but the size-range and condition of the artifacts testifies to the integrity of these sites.

The likelihood of finding intact sites varies from place to place in the dunes because:

1. The northern edge of the dunesheet extends inland for 9 km while the southern extent along the San Antonio Creek is only 4 km. The amount of sand blown inland (and therefore the amount of sand which has moved past any given point) increases the farther north the point. Because sand movement is greater to the north, intact dune sites are more likely to the south.

2. The amount of sand which has blown past a given point is less the farther inland the point happens to be. (If the point is at the shoreline all the down-wind sand must have passed that point. If the point is half way between the shore and the inland edge of the dune sheet, then no more than half as much sand has passed the point.) Intact dune sites are therefore likely to be farther inland.

It may be that intact subsurface sites are present. If these were deposited on dune surfaces, then they will also likely be found inland and to the south. But the possibility exists that sites were deposited prior to the incursion of the recent and intermediate dunes on developed soils resistant to aeolian disturbance. These sites, if they exist, should be relatively intact though they may be buried under many meters of sand. A search for such pre-dune sites would be better informed if data were available concerning the location of buried drainages, terrace edges, old shorelines, and other landforms which correlate with archaeological sites in nearby non-dune contexts.

Important opportunities for the acquisition of data on the morphology of the surfaces underlying the dunes have been missed. For example, little attention was paid to the deep excavations for the MAB, TP-01 and the extensive cuts made for the new roads which were to serve the eastern shelters. Drilling and seismic testing by the Air Force and Union Oil Co. offered the opportunity to acquire valuable information about sub-dune surfaces. Base environmental personnel and contracted cultural resource firms and individuals will, no doubt, have opportunities to recover data from similar activities in the future; these opportunities should not be overlooked.

Lag Deposits: Lag deposits are made up entirely of materials which remain after substantial deflation. They have "lagged" behind. Portions of SBa-226, -713 through -721, and all the unrecorded and recorded near-shore deposits between SBa-721 and -512 are lag deposits. They include the more massive pieces of chipped stone, cracked cobbles, asphaltum globules and sometimes large pieces of bone and the hard Criptochiton plates. Lag deposits are most frequently found near the shore and in fact occur in virtually every swale between SBa-721 and SBa-512 3 km to the north. Whether these are the result of the deflation of a single depositional surface or the merging by deflation of several (once stratified) cultural deposits has not been determined. Also, since excavations have not been undertaken in lag deposits it has not been determined if any are underlain by older undeflated deposits.

Any studies of the morphology of lag artifacts should proceed with caution since lag artifacts have been subjected to intense sandblasting which has obliterated all but the most pronounced surface features. Micro edge wear analysis of lag artifacts is not appropriate. But many tool types are discernable as are raw materials and these may be profitably compared to collections from other undeflated sites to ascertain site function and

chronology. Care must be taken to control for the possible presence of merged deposits. In this light, radiocarbon dating of any organics found in lag sites should be given the highest priority.

Though they are not readily displaced by the wind, even large pieces in a lag deposit have been to some extent lowered by the removal of the underlying sands, and moved downwind by the pressure of the wind. The measurement of this displacement would at least require consideration of the size and shape of the pieces and past wind directions. The complexity of these data argue against attempts to precisely reconstruct the original artifact distributions. Nevertheless, the discrete clusters of cracked cobbles and chipped stone artifacts at SBa-721, for example, are probably more or less representative of activity loci at the site.

Windblown Deposits: Windblown deposits are those containing entirely materials secondarily deposited by the wind. The two clearest examples of windblown deposits are SBa-1193 and -1201.

A large flake and a piece of fire affected rock were found on the surface of SBa-1193 and a large core on the surface of SBa-1201. These showed none of the signs of wind transport nor sandblasting characteristic of all the other artifacts from these two sites and were probably dropped on the surface after the windblown deposits were laid down.

The remaining materials at these sites are all thin waste flakes ranging in diameter from less than a millimeter to several centimeters. Edge attrition measurements indicated that the windblown flakes at both of these sites originated from near-shore sites. Flakes from SBa-1193 originated near SBa-714, and -717 (lag sites) while SBa-1201's flakes probably originated near or at SBa-727, -728, and -1728. The methods described in that study may be useful to investigators in dune areas who discover similar windblown deposits and are curious as to the whereabouts of the source. There seems to be no further archaeological utility in studying windblown deposits.

Complex Deposits: Complex deposits are those which are the result of more than one depositional agent or episode. For example, SBa-581 and -1682 seem to contain two components. The first are secondary deposits of weathered windblown flakes and the others are primary deposits of tools and chipping waste which show no signs of wind transport or polish.

SBa-1728 is a site which seems to be partially deflated in two ways. After the initial depostion of the site (by prehistoric people) the southern portion, which lies in the path of an advancing dune segment, seems to have been repeatedly buried and blown out. In this part of the site, lag deposits overlie strata which have yet to be disturbed by the wind. The site appears to extend for 700 m parallel to the prevailing winds. The deflated downwind portions are at point overlain by sands containing windblown materials deflated from upwind portions. The northern portion, which is out of the path of the advancing dune, remains intact.

Chapter 6

SOIL PROPERTIES OF THE SITES

INTRODUCTION

Soil samples collected by HDR, CCP, and other archaeological participants in the project were analyzed for calcium, phosphorus, pH, color, and particle size in order to establish any possible relationships between soil characteristics of prehistoric human occupation. Concentrations of calcium and phosphorus, important constituents of shell and bone respectively, may indicate relative age and/or length of occupation of a site when used in combination with the soil pH and color. Particle size data may indicate relative age of the dune containing the site as well as separate discrete dune events.

The data represent a fraction of the total sites and samples selected to represent variation in site types, topographic positions, and age. All samples are from columns taken from selected soil profiles. Thus, there are data indicating vertical changes within the profile as well as horizontal or site variations. The samples were all collected at various times in the past and varied significantly in size. A usable quantity was extracted from each sample in the laboratory, and the remainder was discarded.

Because the samples were collected by many different individuals and because descriptions of the samples are often incomplete, it was sometimes difficult to assess the significance of the data. Nevertheless, specific trends are apparent which appear significant and useful. In the following presentation, the procedures used to analyze each soil characteristic will first be discussed. This will be followed by a discussion on the general trends of the data and their significance. (A summary of the data by site is presented in the Basic Data Reports.)

PARTICLE SIZE ANALYSIS

Column samples were selected from a number of sites and non-site dune areas to investigate the variability of sand size distribution vertically and laterally throughout the study area. A sample size of 300 milligrams (mg) was split from original samples and dry-sieved using a series of nested sieves (2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm, and 0.0625 mm) spanning the size range of sand. The samples were mechanically shaken at high intensity for

seven minutes. The contents of each sieve were weighed and taken as a percentage of the total weight. In all cases, the original and final weights agreed within a few tenths of a milligram, a fraction of a percent of the total. Thus virtually no portion was lost during this process that would significantly affect the results.

All samples tested consisted primarily of dry loose sand. However, a number of the samples contained significant amount of organic matter (producing darker colors) and some silt and clay. Since it was possible that the finer material (silt and clay) tended to bind together or to finer sand particles and act as larger particles during dry-sieving, a few samples were dry-sieved and then cleaned by soaking in bleach overnight to eliminate the organic matter. These samples were then rinsed, dried, re-sieved and compared to the original analysis. (A more detailed description of the bleaching procedure appears under Laboratory Processing Procedures in Chapter 3.)

The weight percent data for all samples analyzed were plotted against sand size category. The silt and clay fraction (less than 62.5 microns or 0.0625 mm) for a profile was plotted as percent clay and silt versus depth. In cases where both unbleached and bleached samples were run, the data are superposed so as to compare the results.

All samples showed a similar trend, with the dominant particle size at 250 microns (#60 sieve). In most samples, the next most abundant size is 125 microns (#120 sieve); a few samples contain almost as much 125 micron-size sand as 250 micron-size. There were no major distinguishable general trends sand particle size useful for discriminating between dune units. There is as much vertical as lateral variation indicating that all of the samples analyzed from the San Antonio terrace are of eolian origin and from a similar source.

Bleaching of the samples did not significantly change the sand signature in its overall appearance except to decrease slightly the coarse sand fraction and increase the total silt and clay; the primary sand size remained at 250 microns. Thus, most of the silt and clay was apparently bound together to make coarse sand size particles or was adhering to sand grains. The bleaching did have a significant effect on the percentage of silt and clay, however. The Unit 10 samples from SBa-706 increased from a fraction of a percent silt and clay to 7 to 9 percent. Similarly, samples from Unit F at SBa-706 increased to 9 to 16 percent silt and clay from less than one percent. It is apparent that the particle size analysis is not very useful in evaluating the total increase in the finer fraction over the sand as a possible age indicator, the data however, do indicate similar original source. Additionally, the samples releasing the most silt and clay after bleaching also tended to be the darkest in color, suggesting an intrinsic relationship between strength of color and accumulation of fines.

Heavy mineral (magnetite, ilminite, zircon?, apatite?) were abundant in most of the samples, and in all cases dominated the 62.5 micron fraction. This is noted because these minerals, many of which are iron-bearing, are believed to be at least in part responsible for the reddening of the dunes with time.

COLOR

The moist and dry colors for all samples were taken under natural light by comparing the sample color to those in a Munsell soil color book; all colors are written in Munsell notation. The colors were taken by a single individual so as to minimize error due to differences in color perception. However, the hues are not always consistent vertically when they should be, and some samples that were double-checked tended towards a redder hue. Thus, the color of many of the samples may be off by one hue, with the recorded color tending to be too yellow. The chroma and value measurements were consistent with those double-checked and are assumed to be good. The hue inaccuracies are probably attributable to inexperience of the individual taking the colors.

The soil color proved very useful in distinguishing between A and C horizon material and as a rough indicator of organic matter content. A darkening of the upper part of the profile indicates greater stability and age than in a profile with little or no change in color from the C horizon to the surface. Additionally, color determination allowed for estimating the base, and hence the thickness, of the A horizon where not indicated in field notes.

pH DETERMINATIONS

The pH of each sample was determined using a colorimetric method included within a LaMotte soil test kit. Many pH determinations were cross-checked using a portable pH meter and were found to be in close agreement. Additionally, several determinations of a single sample were made to assess repeatability, and all values came out the same. The pH is accurate to ±0.2 pH value in all cases, and 0.1 in most cases. For the purposes of this project, these determinations and error limits are adequate, and systematic trends are apparent.

The pH in most of the soils was less than 7.0 (acid) and most of those were in the range of about 5.0 to 6.0. Thus, these soils are moderately acid and, dependent upon the presence or absence of shell and the levels of calcium ion, the pH may be significant as an indication of the age and length of use of many of the sites.

There was quite a bit of minor vertical variation in pH for most of the profiles, but there was no systematic trend. The significance of the pH values at various localities and how they relate to the other data will be analyzed below under the discussion on general trends of the data set and relative age of the sites.

CALCIUM AND PHOSPHORUS DETERMINATIONS

Calcium and phosphorus determinations were made by the colorimetric method included within the LaMotte Combination Soil Testing Outfit (Model STH Series). Exchangeable calcium and phosphorus were extracted from the soil using the kit's universal extracting solution (acetic acid + sodium acetate). The leachate was treated with the proper tablets, chemicals and/or color indicators from the soil test kit and compared against color standards on printed cards. It is not known how closely these results would match standard ammonium acetate extractable calcium and phosphorus determined by atomic absorption or some other standard method.

The calcium content ranged from 150 to 1,400 ppm, with control colors at concentrations of 150, 350, 700, 1000, and 1,400 ppm. The sample colors often fell between the control colors, and a concentration range (i.e., 150 to 350 or 700 to 1,000) was recorded. In these cases, the concentration is considered to be at roughly the average between the two values. The accuracy of this method is probably no better than 100 ppm in any case and 200 ppm in some cases. Nevertheless, the range was wide enough to allow for this amount of error and still determine specific trends as reported below in the discussion section. The determinations were repeatable: several samples were run three times with similar results, thus strengthening the method and results.

The phosphorus determinations yielded results similar to the calcium, but with concentration ranges of 10 to 200 ppm. The control colors were given as ranges (i.e., 10 to 25, 25 to 50, 50 to 75, 75 to 150, 150 to 200) and therefore are only approximate. In determining the phosphorus content of the samples, a high and low (H and L) range were recorded depending on the strength of the color, the H reading probably corresponding to a value slightly below the upper limit and the L reading slightly above the lower limit. The phosphorus concentrations, then, are only approximate, but because of the wide range of concentrations they are useful in this analysis.

A compounding problem with phosphorus is that results vary with the determination method--that is, phosphorus concentration may be determined by one of several standard laboratory techniques, all of which individually yield consistent results but disagree with each other. This is due to the extent of removal of phosphorus not only from the exchange sites but also from origin crystal lattiel sites within the original minerals; different methods therefore extract phosphorus to varying degrees. Thus, these results can be used only in relation to others determined by the same method. This does not affect the interpretations of the data set in this report in a general sense, but may affect comparisons with data from other areas. Based on preliminary findings, it is likely that the phosphorus concentrations given for these sites are lower than would be determined by standard laboratory methods; phosphorus content commonly exceeds 250 ppm in anthropic epipedons (an anthropic epipedon is one formed by long continued use by men; they are typified by a high phosphorus content) at midden sites in

other areas and probably does here as well, although the data indicates a lower value.

Both calcium and phosphorus determinations were run by the same person, thus reducing error due to variations in color perception by different individuals. This and the reproducibility strengthen the chemical data and the resultant interpretation.

GENERAL TRENDS

The five physical and chemical parameters discussed above, in conjunction with the type and abundance of artifactual material, indicate specific trends which provide information on relative age, geological stability and significance of studied sites. Sites occur on dunes which are primarily of two ages, the older containing a dark colored and and fairly thick A horizon having some natural characteristics that may be confused with middens, such as color and higher concentrations of base cations.

The absolute age of the dunes which contain the middens is suspected of being geologically young, less than 2000 B.P. (see Chapter 4). The terms young, old, and older which are used in this analysis are relative in the context of the prehistoric chronology for the region; young probably refers to antiquity within the Late Period, possibly even protohistoric; old and older may refer to Middle Period antiquity. Because the age relations are relative, there is a fair amount of uncertainty.

The soil color darkens naturally with age as organic matter accumulates. Human occupation and the development of a midden (also an accumulation of organic matter) also produce soil darkening. The dark color in the older dunes is therefore not diagnostic of human activity, but it may be a useful indicator in the younger dunes, where dark and thick A horizons on dune surfaces associated with artifactual material suggest that the darkening may be in part due to human occupation.

The pH, calcium, and phosphorus data, taken in conjunction with the presence or absence of shell, bone and lithic assemblages, is the best indicator of site use and age. In this region, a large amount of the extractable calcium is derived from decaying and dissolving shell associated with human occupation. Similarly, high phosphorus concentrations are commonly associated with middens as a result of decomposition of bone. As the calcium concentration increases, pH should similarly increase and eventually become alkaline. Because each site varies to some degree in its soil parameters, each of the sites studied will be discussed individually or as small groups.

Because of the relationships between sites are relative, differences should apply only to this area. The values of low, moderate, and high as used in this analysis are not necessarily meaningful when compared to similar analyses outside the study area.

Units of sites SBa-706 and the transect of shovel test pits (STPs) along a communications line through this site (referred to as FOCL) have both fairly high pH (slightly acid to alkaline) and a very high calcium and phosphorus concentrations. Site SBa-706 has relatively abundant shell, bone and lithics, which, in addition to the chemical data, suggest a fairly old and long term (long term as used here indicates sufficient time to dissolve shell and bone; it may be on the order of hundreds of years) rather than a single season habitation site. Lithics are recorded as present along the FOCL transect, although their density is unknown, and there are no data for shell and bone. The chemical data suggest sufficient time for shell and bone to increase the calcium and phosphorus contents as well as the pH, and therefore an age of at least several hundred years is suggested for this site.

Sites SBa-1176, -1170, -1036, and probably SBa-1177 and -1179, are all slightly acid to slightly alkaline (SBa-1177 and -1179 are slightly to moderately acid), have moderately high to very high calcium concentrations, low to moderate phosphorus concentrations, moderately abundant lithics (where data are present), and little or no shell (with the exception of SBa-1179). The higher pH and high calcium concentrations are attributed to dissolved shell, which has for the most part been absorbed onto ion exchange sites. This indicates that either 1) these archaeological sites did not have enough shell to endure the slow leaching process and were occupied for only a short time period, or 2) they may be quite a bit older than some of the other sites, and sufficient time has elapsed to dissolve the shell. Both possibilities imply non-historic habitation, but fairly light soil colors for sites SBa-1176 and -1177 indicate non-stable soil conditions and preclude very old ages for these sites.

SBa-1174 shows properties of the two above groups, such as a slightly to moderately acid pH, high calcium, low to moderate phosphorus concentrations and a significant amount of bone, shell, and some lithics. This site is interpreted to be akin to SBa-706 as far as the chemistry indicates, that is, only the order of several hundred years old, but the absence of significant lithics suggests it was not a habitation site.

SBa-1718, -998, -1155, and -1066 have low pH and phosphorus content, yet fairly high calcium content. Shell and bone remains are rare and lithic concentrations are low. Additionally, all have dark A horizons. The calcium could and probably is a result of soil formation rather than human occupation (and shell dissolution) because of the apparent lack of cultural material. These sites probably witnessed very short-term use and limited activity variation based on the chemistry and cultural content.

SBa-980 and -1070 also have a low pH (acid) and moderately high calcium concentrations, yet contain abundant lithics and shell. This suggests that calcium being released from the shell during dissolution is being locked up on exchange sites within the soil. As such, the pH remains low. Through time, enough calcium ion will be released so as to saturate the soil and increase the pH. Because of the pH, calcium and shell content relationships, these sites are interpreted as being young and not of long habitation.

SBa-1193 is similar to SBa-980 and -1070 in all respects except that even the calcium concentration is low. This suggests that SBa-1193 is the youngest site and does not contain an older component. The light color of the soil indicates that the site is within a relatively active dune area, and supports the above conclusion.

CONCLUSIONS

The soil properties of the studied sites suggest a trend in age and length of use dependent upon pH, calcium and phosphorus concentrations, color, and cultural content. Some suspected midden may be only developed soils with a few scattered lithics. The oldest and longest inhabitated sites should have a higher pH, high calcium and phosphorus concentrations, and contain abundant shell and lithics. Younger sites have a low pH and calcium concentrations, yet have abundant (or at least some) shell and lithics. Some sites appear to have been short-lived but are older than the young sites; these are acid to slightly alkaline, have higher calcium and phosphorus concentrations, have abundant lithics, yet little or no shell (mostly dissolved).

Chapter 7

PREHISTORIC CHRONOLOGY

THE DEVELOPMENT OF A VANDENBERG REGION CHRONOLOGICAL SEQUENCE

As with most other regions in California, the prehistoric chronological sequence for the Vandenberg region is still quite crude. In part, this is due to the lack of published analyses of archaeological collections from the Vandenberg region, but it is also caused by the difficulties confronting the development of chronological sequences throughout California. Regional sequences are constructed on the basis of changes through time in the occurrence of specific artifact forms. In California, however, archaeological sites contain few artifact forms sensitive to time, and these are usually in low frequencies except in cemeteries. Compared to other regions of North America, therefore, contemporary California archaeology depends more on chronometric dating to determine the age of archaeological sites and less on chronological sequences.

Since the investigations of Ruth in the 1930s (see Chapter 2), the chronological sequences developed for the Santa Barbara Channel region to the southeast have been applied to the Vandenberg region, largely because many of the same artifact forms occur in both regions. The principal Santa Barbara Channel sequence applied to the Vandenberg region has been that proposed by Rogers (1929) which, as mentioned in Chapter 2, was referenced by both Ruth and Carter. This sequence consists of three gross periods, each of which Rogers felt represented the occupation by genetically discrete populations, or "peoples," to use his term. He referred to these three successive populations as the Oak Grove People, the Hunting People, and the Canalino People. Since Rogers' sequence was based on stratigraphic relationships between site components, it has stood the test of time and is still used by contemporary archaeologists, the only significant modification being to use Rogers' terms to refer to periods characterized by a set of artifact assemblage characteristics rather than to different "peoples." Several modifications or improvements to Rogers' original three-part sequence have been proposed through the years (Orr 1943; Wallace 1955; Harrison 1964, 1965; Harrison and Harrison 1966; Warren 1968), but none has gained wide acceptance. Likewise, a sequence proposed by Olson (1930) as an alternative to Rogers' is often referenced along with Rogers' (e.g., Carter 1941), but it has not gained as much popularity because it does not include the earlier portion in the regional prehistory as does Rogers'.

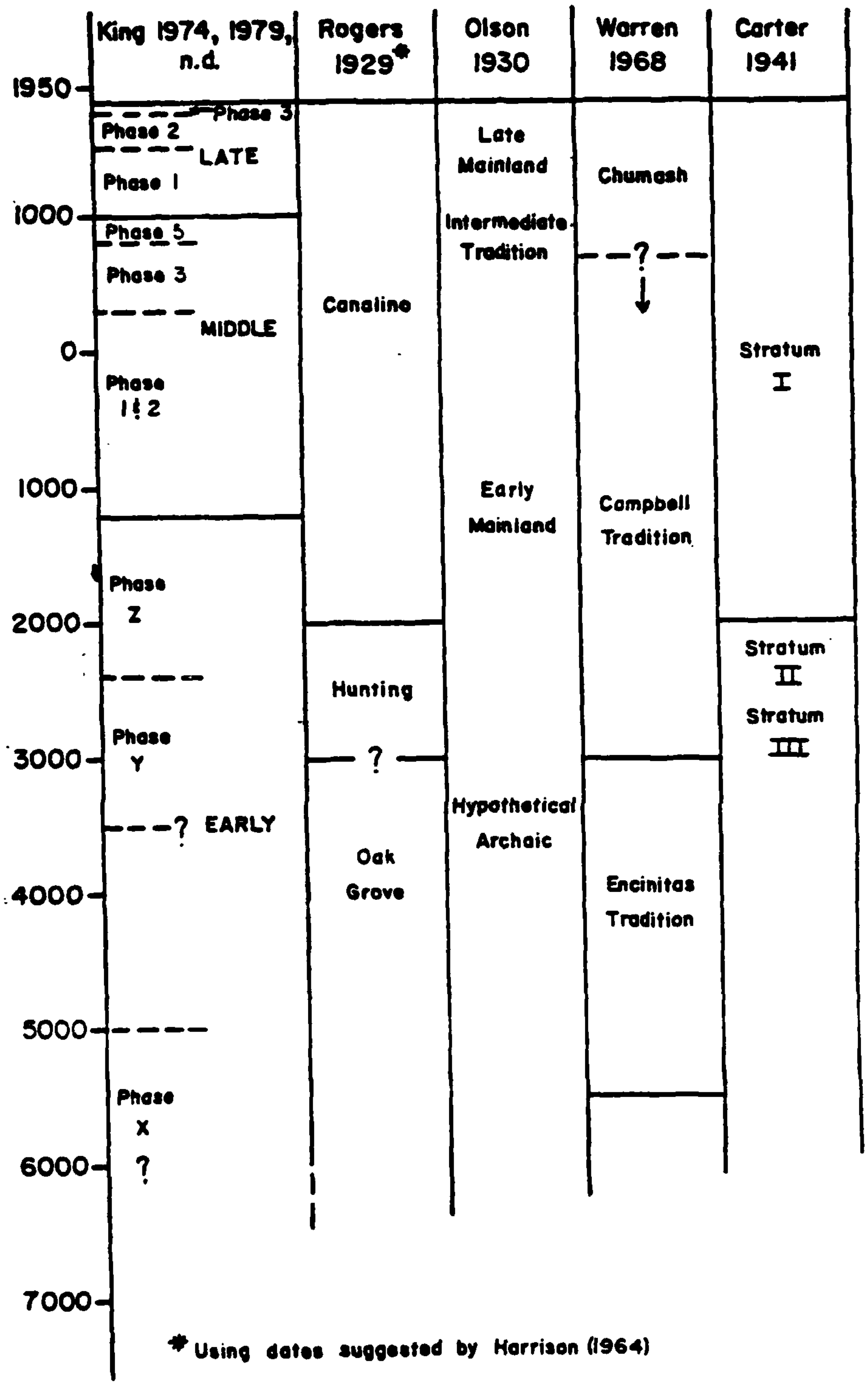

Figure 7-1. Condordance of Chronological Sequenes for Santa Barbara County (after Glassow et al. 1981:2-17)

When radiocarbon dating became available in the 1950s, its application validated the general aspects of Rogers' sequence, but in recent years, with the increase in the number of radiocarbon dated assemblages, Rogers' three periods have been recognized to be really only glosses, and therefore his sequence does not provide a basis for modern studies of prehistoric cultural development. The current trend, therefore, is toward the use of radiocarbon dating to assess directly the position in time of site occupations and to discuss aspects of cultural development without reference to a regional sequence.

Despite this trend, a much improved sequence for the Santa Barbara Channel recently developed by C. King (1981) is gaining some popularity. Based on stylistic changes in shell, stone, and bone beads and ornaments which are most frequently found as grave goods in cemeteries, this chronological scheme ties particular styles and their relative frequencies to a series of three periods, Early (8000 to 3350 B.P.), Middle (3350 to 800 B.P.) and Late (800 to 150 B.P.). Each of these periods is divided into phases and in some cases subphases. Radiocarbon dated burial assemblages were used to assign absolute dates to the beginning and end of each phase or subphase, although these dates in many instances are very tentative. King's sequence has some vague similarities to Rogers', largely because, both divide the sequence into three periods (see Figure 7-1). However, the two cannot be compared beyond noting that Rogers' Oak Grove period corresponds fairly closely with King's Phase X. Unfortunately, the use of King's sequence is hampered by the scarcity of beads and ornaments in archaeological deposits other than cemeteries, and its application in this report is therefore restricted to references to his chronological devisions, which are taken to represent most faithfully the currently available data.

During the course of archaeological investigations on south Vandenberg in connection with the construction of Space Transportation System facilities, 28 radiocarbon dates were obtained from 13 archaeological sites (Martz 1976; Glasslow et al. 1981, Appendix 2). These dates are distributed through 8,500 years of prehistory, giving witness to the intensity of occupation in the Vandenberg region over several millenia of prehistory. Martz (1976) performed a preliminary analysis of the relationship between the radiocarbon dates and artifact types or classes suspected to have restricted occurrences during prehistory. Unfortunately, the artifact classification she used (based on distinctions recognized in the collection catalog) were too crude to reveal more than general trends already recognized by Rogers, Olson, and Carter.

Although research in the vicinity of the San Antonio Terrace has not yet yielded radiocarbon dated site components comparable in number to those on south Vandenberg, available data indicate that it was likely as early. Mentioned in Chapter 2 was the possibility that Carter's excavations at SBa-125, just north of the terrace, may have encountered deposits dating to the beginning of King's Early Period, as well as evidence of later occupation, and that cemeteries excavated by Ruth and Spanne north of Shuman Creek and adjacent to the Barka Slough yielded beads and ornaments assignable to

King's Middle Period. On the basis of the existence of Chumash villages documented by Spanish expeditions in the late 1700s, Late Period occupation is assumed to have existed on the periphery of the San Antonio Terrace (see Appendix I).

Dating the Sites Investigated

In light of the above discussion, it should be apparent that the two approaches to the absolute dating of the sites investigated during the course of the Vandenberg MX Archaeological Project are radiocarbon dating of organic remains contained within the sites and cross-dating by reference to time-sensitive artifact types. However, only three sites provided organic remains--in this case, shell--in sufficient quantities for radiocarbon dating, and very few artifacts were encountered that have any sensitivity to time, these being two shell beads and 25 typeable projectile points. Two other less conventional approaches to dating were attempted with some success. The first involved analysis of the chemical constituents of site soils under the assumption that there are some regular changes in site soil chemistry through time, and the second involved dating the landforms on which sites occur, particularly the intermediate dunes on whose surfaces were found many of the sites.

Considering first the application of radiocarbon dating, only three sites yielded shellfish remains from relatively discrete proveniences in quantities sufficient to justify radiocarbon dating. In all three instances, the shell used for dating was California mussel (<u>Mytilus</u> <u>californianus</u>), and provenience consisted of a level within a test unit or a shovel test pit (STP). The dates run by Beta Analytic of Coral Gables, Florida, and their proveniences are presented in Table 7-1).

Table 7-1. Archaeological Radiocarbon Dates

Site	Unit No.	Level	Lot No.	Lab. No.	Date B.P.
SBa-706	5	20-40	4435	6672	660±70
SBa-980	1	20-40	4465	6773	600±50
SBa-1179	(SW½)SE/4E	15-20	63	6771	730±50

Robinson and Thompson (1981) have argued that radiocarbon dates derived from shell are too old because of the effect of the oceanic radiocarbon reservoir from which living shellfish obtain C-14. Their interpretation of data originally reported by Berger and others (summarized by Taylor 1978:50-53) is used to infer that California coastal dates are between approximately 600 to 700 years too old. If this were the case with the dates listed above, an essentially modern age would be inferred. Yet, the absence of historic artifacts such as glass beads from the excavations at these sites implies that they are at least 200 years old. Futhermore, Taylor (1978:52) reports paired shell and charcoal radiocarbon dates from Pacific Coast archaeological sites (i.e., each pair is derived from one provenience) which indicate

that the difference may be much less than 600 to 700 years. Although the number of parts is small (11), the average greater age of the shell dates is between 50 and 100 years, with a range between 400 years less age and 660 years greater age of the shell dates compared to the charcoal dates. (Generally, each date within the pair is within one sigma of counting error of the other.) Moreover, a shell date from a site on Santa Cruz Island (SCrI-145) is only 80 years older than a charcoal date from the same stratigraphic level (Glassow 1980:82-83). This pair is especially significant because it is derived from a relatively thin site deposit in a habitat devoid of burrowing animals, and the site is adjacent to an oceanic environment probably very similar to that of the Vandenberg sites. In conclusion, the reservoir effect on shell dates is probably not as great as surmised by Robinson and Thompson, and it is reasonable to assume that the three dates listed above are indeed close to what they would be if they had derived from charcoal instead of shell.

All three dates fall within the first phase of the Late Period and are consistent with other time indicators from these sites, as shall be seen. Unfortunately, these three radiocarbon dated sites cannot be taken as representative of all sites on the San Antonio Terrace or even of the sites investigated. The sample is too small in either respect, and it is biased toward the few sites with relatively high densities of shellfish remains. These dates may indicate, however, that sites with denser midden debris tend to date within the Late Period, a possibility which is considered in the data analyses presented in later chapters.

As mentioned, time-sensitive artifacts occurring in the collection are restricted to two classes: shell beads and projectile points. Only two shell beads were encountered, which is not surprising in light of their rarity in site deposits and the relatively small volumes excavated at each site. SBa-1154 yielded an abalone nacre disc bead (made from the mother-of-pearl portion of a Haliotis sp. shell), which may date to either the Middle or Late Period according to King's sequence (C. King 1981, Figure 6). This bead is not, therefore, very sensitive to time. The other bead encountered is a full-lipped Olivella biplicata bead, from SBa-1753. This bead type is very sensitive to time, occurring only during subphase L2b of the Late Period. This post-contact subphase dates between A.D. 1650 and 1782, just prior to the founding of Mission Santa Barbara. The date reflected by this bead is consistent with the ethnohistoric evidence of seasonal use of the San Antonio Terrace during this same period of time (see Appendix I).

Projectile point types represented in the artifact collections comprise the best available evidence of some time-depth in the aboriginal use of the San Antonio Terrace. As described in Chapter 8, four basic types of projectile points occur in the collections: large corner-notched, large contracting stemmed, small leaf-shaped, and small concave-based. The two large point types, probably used to tip simple spears or darts used with a spear-thrower, are generally indicative of Middle Period occupation along the coast between San Luis Obispo County to the north and Los Angeles County to the

south, while the two small point types, reflecting the use of the bow-and-arrow, are generally indicative of Late Period occupation along the same stretch of coastline.

Although stratigraphic excavations bear out the relative time-differences between the large and small point types--for instance, Carter's excavations at SBa-125, Lathrap and Hoover's (1975) at SBa-205, and Greenwood's (1972) excavations at Diablo Cove (see Glassow 1980b), there are nonetheless some problems in using the point types as time-markers. The worst problem is that both large point types occur sporadically in both earlier and later assemblages. Mentioned in Chapter 2 was the occurrence of corner-notched (or square-stemmed) points in terminal Early Period sites, and although they occur most prevalently in the Middle Period levels of SLO-2 at Diablo Cove (Greenwood 1972:13), they do occur in Early and Late Period levels as well. The stratigraphic distributions of contracting stemmed points are similarly blurred. In particular, they occur relatively commonly in Late Period contexts (e.g., the distribution of long contracting stemmed points at SLO-2 [Greenwood 1972:13]). Consequently, large corner-notched and contracting stemmed points are only suggestive of Middle Period occupation; they are not unequivocal indicators.

There are stronger grounds for assuming that the small projectile point types are restricted to terminal Middle Period and Late Period contexts. Both are presumably arrow point types, which generally do not occur in western North American site components dating prior to about A.D. 500 (see, for example, Thomas 1981:20, 30-32 for the Great Basin, and Plog 1979:114-115 and Cordell 1979:134 for the northern Southwest, two areas where recent chronological studies are of sufficient precision to be relatively confident of this date). The small concave-based point type fairly certainly is restricted to a Late Period context. Points of this type are often predominant in the Late Period components at sites known to have been Chumash villages at the time of European contact. The upper levels of SBa-205 at the mouth of Jalama Beach (Lathrap and Hoover 1975:30) and the bulk of Ven-3 near Ventura (Greenwood and Browne 1969:12-13) are examples of such site components containing high proportions of small concave-based projectile points. Although dating of the introduction of this type in southern coastal California is still imprecise, there has been broad agreement that it may have occurred sometime between A.D. 700 and 1200 (Wallace 1955; Warren 1968:4-5; King, Blackburn, and Chandonet 1968:93). The small leaf-shaped point (also called lanceolate or convex-based) also appears to be largely a Late Period type, but there is evidence that its use began earlier than the use of the small concave-based type and that it became less important later on in the Late Period. The latter interpretation is implied by the lesser importance of the leaf-shaped type in the terminal Late Period deposits at Ven-3, but its greater importance in sites representing, at least in part, earlier Late Period occupation, such as Arroyo Sequit (LAn-52) (Curtis 1963:18; compare data from the 1959 excavations in historic portion of the site with those from the 1963 excavations in the prehistoric portion). Evidence that the convex-based

point type may actually extend back in time to the terminal Middle Period is provided by its stratigraphic distribution through Late Period and upper Middle Period levels at SLO-2 (Greenwood 1972:13).

It is perhaps noteworthy that leaf-shaped points are more abundant in the San Antonio Terrace collections than concave-based points. If indeed there is some temperal differentiation between these two types, with the concave-based being relatively later than the leaf-shaped, it implies that use of the San Antonio Terrace was more intensive earlier in the Late Period than later. Better control over the dating of these two types and larger samples from the San Antonio Terrace would be needed before this possibility can be properly evaluated.

In the analysis of the chipped stone items in Chapter 9, Bamforth groups the four projectile point types into two categories: "large," consisting of the corner-notched and contracting stemmed types, and "small," consisting of the concave-based and leaf-shaped types. He considers the large category to be indicative of "early" occupation and the small category of "recent" occupation, and he uses the date of ca. A.D. 500 as the division between the two periods. In light of the discussion just presented, his use of the point types as time-markers in this fashion is reasonable, especially since the occurrence of the two groups of sites is mutually exclusive. Nonetheless, it should be born in mind that projectile point frequencies are very low, which enhances the possibilities of sampling error, and that the large point types can occur in post-A.D. 500 contexts as well. Bamforth's use of the date of A.D. 500 to divide the two periods is also reasonable since leaf-shaped points appear to occur in terminal Middle Period contexts. On the other hand, large contracting stemmed points were likely still popular after A.D. 500, so a later date could just as easily be used. In the end, Bamforth's use of "early" and "recent" labels are best thought of as indicating relative differences in time that are not necessarily tied to an established sequence such as C. King's.

In light of the limitations to the application of radiocarbon dating and cross-dating by means of time-sensitive artifact types, an effort was made to develop a less conventional dating technique that could potentially be applied to a large proportion of the sites on the San Antonio Terrace. This technique involved analysis of the chemical properties of site soils under the assumption that certain chemical changes occur at a regular rate beginning at the time of site abandonment. The analysis of the soil chemistry of the sites, presented in Chapter 6, indicates that this approach to dating has potential, and in Chapter 9 Bamforth observes a basic consistency in the inferences of relative ages of sites based on soil chemistry and projectile point typology. As indicated in Chapter 6, the principal factor perturbing inferences of site age from soil chemistry is the intensity of occupation, which clearly varied considerably among San Antonio Terrace sites. It is possible, however, that this obstacle may be overcome in the future if more sophisticated soils analysis involving the capabilities of a soils analysis laboratory are undertaken in place of the simple analyses possible with the portable kit used in the context of this project.

The final approach to dating applied to San Antonio Terrace sites relies on the fact that many of the sites sit atop dunes formed sometime during prehistory. As described in Chapter 4, much of the San Antonio Terrace is covered by mostly stabilized dunes exhibiting distinct dunal morphology, implying a relatively young age. Referred to as dunes of intermediate age, or more conveniently, intermediate dunes, R. Brown infers in Chapter 5 that they are approximately 2,000 years old based on minimal soil development on the dune surfaces, the thinness of the organic layers in the wetland between the dunes, and radiocarbon dates of organics in the dune soils. This relatively young date is supported by the date of a midden underlying morphologically similar coastal dunes on south Vandenberg. This site (the lowermost component of SBa-670) yielded a radiocarbon date of 3935 B.P., indicating that the fifteen-meter high dune above the midden must be younger (Glassow et al. 1981:8-29).

Sites yielding small projectile points are known to post-date the formation of the intermediate dunes on the basis of the known ages of these projectile point types and the three radiocarbon dates. Sites yielding large projectile points could, however, pre-date the intermediate dunes, but significantly, all these sites are partly or wholly on intermediate dune surfaces, implying that they, too, are younger than about 2,000 years. Older sites, if they exist, must lie on the old or older dune surfaces of the San Antonio Terrace, perhaps in some cases below deposits of intermediate dune sands.

Summary

Despite the considerable difficulties in establishing the ages of the sites investigated in the course of the Vandenberg MX Archaeological Project, progress has been made in discerning the antiquity of prehistoric occupation on the San Antonio Terrace. Dunal morphology and degree of soil development indicate that sites on the intermediate dunes cannot be older than about 2,000 years, but within this interval it is possible to separate some of the sites into two different periods on the basis of associated projectile point types. The approximate date of A.D. 500 is used to divide the two periods one from another. In terms of C. King's chronological sequence, significant use of the San Antonio Terrace by prehistoric populations apparently began during the later phases of the Middle Period and persisted through the Late Period into the time of missionization by the Spanish.

Chapter 8

CHERT SOURCE IDENTIFICATION

INTRODUCTION

In order to understand better patterns of lithic artifact use, it is important to know the origins and physical qualities of the most abundant rock type used for artifact manufacture within the area—in this case, chert. Chert is herein defined as a dense, vitreous, fine-grained, siliceous rock which is very tough and breaks with a conchoidal fracture. Chert outcrops were studied in an approximately 200 km^2 area which extends from the Santa Ynez River mouth to the Santa Maria River mouth and inland several kilometers.

The tremendous number of chert beds or other exposures of chert (terraces, beaches) and the variability within and among chert outcrops precludes the use of techniques such as neutron activation for the sourcing of lithic artifacts. Instead, a simpler and more reasonable approach was undertaken utilizing basic field mapping and sampling. This investigation had three main goals, all relating to the overall task of matching lithic artifacts to sources, or the elimination of some areas as likely source terrains for specific cherts from which artifacts were made. These three goals were:

1. Identification of all chert sources in the study area. These sources were mapped according to type of occurrence.

2. Determination of the variability and distribution of chert color in the study area. Chert color categories were identified and mapped to aid in the sourcing of lithic artifacts.

3. Development of an exploitation potential index which rates chert quality, resource density, and accessibility at any given outcrop. From this, various outcrops can be considered or demerited as possible artifact sources by the "usability" of the chert found there. The results were plotted on a map.

The vast majority of all chert found in the study area is contained within, or derived from, the Monterey Formation of Miocene age (5-16 m.y.). Monterey chert differs from typical flint formed by volcanic processes or

through crystalization of inorganic aqueous solutions. Instead, Monterey chert is formed by the dissolution of siliceous microfossils (diatoms) after burial and the subsequent recrystallization of this material is glassy, laminated, quartz chert. Microfossils are only rarely preserved during this recrystallization process (Grivetti 1982), and are always heavily corroded.

Chert is also locally available from the Jurassic Franciscan Formation. However, this chert comprises a minute quantity of the total chert found in the study area.

FIELD METHODS

Prior to commencement of field work, the study collection was spot examined in order to become familiar with the amount of variability in chert color and quality found in artifacts of the area. Field work consisted of a reconnaissance sampling and mapping survey of the entire study area utilizing published geologic maps (Woodring and Bramlette 1950; Dibblee 1950) to identify outcrops which potentially contained chert. It is important to note that a gap approximately 12 km wide in the vicinity of San Antonio Terrace exists between the maps of Woodring and Bramlette and Dibblee. Chert outcrops within this "gray" zone were, however, identified, mapped, and examined.

The field survey consisted of identifying the formation and member within the formation of which the outcrops were part, locating sample sites onto USGS 7.5 feet topographic quadrangle maps (topographic maps), transferring published geology or of previously unmapped outcrops onto topographic maps, describing of the chert outcrop (see Table 8-1), and collecting of representative chert samples from specific sites within an outcrop area. The set of USGS maps showing the locations of sample sites, as well as the chert samples, are currently housed in the UCSB Department of Anthropolgy.

It was originally hoped that each bed at every outcrop could be sampled. However, lateral variability of beds, lack of continuous exposure, and the sheer number of beds and clasts (in terraces, beaches, streams) precluded such a treatment. Instead, color variability and collection of samples from distinctive beds at particular outcrops was emphasized during sampling. Samples collected were generally fist size or smaller due to the difficulty in transporting larger pieces.

POTENTIAL CHERT SOURCES

Approximately 30 sites were sampled and described, providing a representative data base from which to group potential chert sources according to occurrence. Five categories are recognized: middle Monterey bedrock, other Monterey bedrock, terraces and stream beds, beaches, and Franciscan bedrock. These outcrop types are described below; their locations are shown on the topographic maps mentioned above.

Table 8-1. Characteristics of Chert Outcrops, Vandenberg Air Force Base and Vicinity.

SAMPLE NUMBER	LOCATION	OUTCROP TYPE	COLORS	CHERT DESCRIPTION	EXPLOITATION POTENTIAL* S	P	C	E	EP
100	southern edge of Burton Mesa	terrace; other Monterey bed-rock with no chert	yellow-red laminated; minor tan, gray, brown; no very black	angular to well-rounded cobbles in terrace cover upper Monterey bedrock which contains no chert; cobbles generally squant to round; not tabular	2	2	1	2	7
101	beach area N of Purisima Point	middle Monterey bedrock; beach	very black abundant; minor gray-blue-brown; very minor yellow	middle Monterey bedrock: thin- and thick-bedded chert abundant, many chert beds surrounded by white, punky material, some zebra striped chert; beach material: large boulders abundant, generally highly fractured; smaller chert cobbles also abundant; many unfractured	bedrock 3	3	3	2	11
					beach 3	3	3	2	11
102	Lions Head beach	middle Monterey bedrock; minor beach; minor terrace	very black; minor gray-blue-brown in beach	middle Monterey bedrock: thin and thick beds, always highly fractured white laminae and blebs common; beaches not abundant, highly fractured	bedrock 2	1	3	1	7
					beach 2	1	1	2	6
					terrace 2	1	1	2	6
103	1.25 km SE of Lions Head	stream bed; minor terrace	gray-blue-brown	round and tabular clasts	2	2	1	2	7
104	2.25 km SE of Lions Head	other Monterey bedrock	gray-blue br wn	thin, brecciated beds and nodules	1	1	1	1	4
105	1.8 km SE of Lions Head near VAFB Hut 8, 1957	middle Monterey bedrock; very minor terrace	gray-blue-brown	beds thin to thick, folded, generally fractured; exposed only locally	3	2	3	1	9
106	2.5 km SE of Lions Head	middle Monterey bedrock	grey-blue-brown	same as 105	3	2	3	1	9
107	3.5 km SE of Lions Head	very minor middle Monterey	gray-blue-brown	very poorly exposed, highly fractured	1	1	1	1	4

Table 8-1. (Continued).

SAMPLE NUMBER	LOCATION	OUTCROP TYPE	COLORS	CHERT DESCRIPTION	EXPLOITATION POTENTIAL* S	F	C	E	EP
108	4 km SE of Lions Head	terrace	gray-blue-brown; no very black	clasts equant and tabular most fractured; large variability of clast size	2	1	3	2	8
109	4.5 km SE of Lions Head	middle Monterey bedrock	gray-blue-brown	good exposures of folded thick to thin beds, generally fractured	3	2	3	1	9
110	0.25 km S of 109	terrace	gray-blue-brown	clasts mostly small, very fractured; equant	1	2	3	2	8
111	near point where railroad enters Shuman Canyon	terrace	gray-blue-brown, very minor yellow	manmade exposure of equant and tabular clasts; large variability of clast size	2	2	1	2	7
112	N edge of Burton Mesa 5 km inland from mouth of San Antonio Creek	terrace	minor very black; minor gray-blue brown	round clasts to cobble size; exposed along man-made telephone roadcut, natural exposure limited to occasional clasts weathering out of hillside	2	2	1	2	7
113	0.5 km E of sample site 112	other Monterey bedrock; very minor terrace	other Monterey bedrock: white, tan; terrace: very black	bedrock: equant-weathering very thin beds terrace clasts very scarce, very small	bedrock				
					1	2	1	1	5
					terrace				
					1	1	1	2	5
114	2 km E of sample site 112	natural canyon exposure of other Monterey bedrock; man-made exposure of terrace	bedrock: white, minor very black terrace: yellow-red laminated some with very black cores	bedrock: very thin beds some zebra striped	bedrock				
					1	2	1	1	5
				terrace: round clasts of varying size, natural exposures poor	terrace				
					2	1	1	2	6
115	0.25 km W of sample site 114	man-made exposure of other Monterey bedrock; man-made exposure of terrace	same as 114	bedrock: same as 114	bedrock				
					1	2	1	1	5
				terrace: large rounded clasts; none collected natural exposures poor	terrace				
					3	1	1	2	7

Table 8-1. (Continued).

SAMPLE NUMBER	LOCATION	OUTCROP TYPE	COLORS	CHERT DESCRIPTION	EXPLOITATION POTENTIAL* S	F	C	E	EP
116	2 km S of sample site 114	man-made exposure of terrace	yellow-red laminated only rarely with very black colors	small, rounded clasts; natural exposures poor	2	1	1	2	6
117	1.5 km N-NE of airport tower	man-made exposure of terrace; very minor chert	some very black? minor zebra striped	man-made exposure of terrace contact with bedrock; rhyolite clast found	1	1	1	2	5
118	0.75 km S-SE of sample site 100	man-made exposure of terrace; minor man-made exposure of other Monterey bedrock	terrace: yellow-red laminated	terrace: clasts small; natural exposure poor	terrace 1	1	1	2	5
			bedrock: whites, tans	bedrock: very little actual chert; beds very thin	bedrock 1	2	1	1	5
119	2 km N of Surf	middle Monterey bedrock; terrace beach	all: very black; some black and white laminated	bedrock: thin to thick beds of massive very black chert surrounded by white punky material; some beds tightly folded	bedrock 3	3	3	2	11
				terrace: very black tabular boulders and cobbles	terrace 3	3	3	2	11
				beach: tabular cobbles of unfractured, thick chert, scarce	beach 3	3	2	2	10
120	2 km N of sample site 119	beach, terrace, middle Monterey bedrock	very black; terrace with minor white	terrace: round clasts, generally small	terrace 2	3	3	2	10
				beach: small to large tabular clasts	beach 3	3	3	2	11
				bedrock: generally thin-bedded, locally thick-bedded; thin beds generally highly fractured, thicker beds less fractured	bedrock 3	3	3	1	10

Table 8-1. (Continued).

SAMPLE NUMBER	LOCATION	OUTCROP TYPE	COLORS	CHERT DESCRIPTION	EXPLOITATION POTENTIAL* S	F	C	E	EP
121	3 km S of Purisima Point	beach, terrace middle Monterey bedrock	very black minor gray-blue-brown in beach and terrace materials	beach: large, tabular unfractured, abundant some very large, fractured clasts	beach				
					3	3	3	2	11
				terrace: same as beach above	terrace				
					3	3	3	2	11
				bedrock: thick, tabular unfractured beds surrounded by white, punky material	bedrock				
					3	3	3	2	11
122	13th street at S edge of Burton Mesa	other Monterey bedrock; man-made cut	gray-blue-brown; some white	other Monterey bedrock sampler site--not a possible quarry site because it is a man-made site; however, site is representative of chert in area	1	2	1	1	5
123	on Brown Road 4 km W of its intersection with Hwy 1	man-made exposure of middle Monturey bedrock	very black; some zebra striped	thin beds, no natural exposure	1	3	1	1	6
124	outcrops 1.5 km E-NE of Mount Lospe	middle Monterey bedrock	gray-blue-brown	local exposures of thin to thick bedded chert; local evidence of prehistoric quarrying activities (many flakes of of similar rock type in close proximity to outcrops)	3	3	3	1	10
125	Brown Road 2 km E of Point Sal beach	terrace	gray-blue-brown; some yellow-red laminated	generally small clasts, generally fractured; no very black chert here, but very black flakes are present at the site	2	1	1	2	6

Table 8-1. (Continued).

SAMPLE NUMBER	LOCATION	OUTCROP TYPE	COLORS	CHERT DESCRIPTION	EXPLOITATION POTENTIAL* S	F	C	E	EP
125	Mussel Rock	middle Monterey bedrock; terrace; beach	very black minor gray-blue-brown in terrace materials	bedrock: thick unfractured, tabular beds surrounded by white, punky material	bedrock				
					3	3	3	2	11
				terrace: large, tabular, unfractured, abundant	terrace				
					3	3	3	2	11
				beach: same as terrace above, but with some clasts very large	beach				
					3	3	3	2	11
126	Point Sal	Franciscan	red	cherts, red, nonlaminated, usually very fractured, very small, and very difficult to extract	1	1	1	1	4
128	Shuman Quarry	no chert							N/A
129	0.5 km E of Mount Lospe	middle Monterey bedrock	gray-blue-brown	exposures poor, good locally only because of roadcut; thin to thick, tabular beds	2	3	3	1	9
130	2 km SW of Mount Lospe	terrace	gray-blue brown; minor	very few clasts; clasts small, round	1	2	1	2	6

Middle Monterey Bedrock

The Monterey Formation was divided into an upper, lower, and middle member by Woodring and Bramlette (1950). The middle member is especially important to this study because it is characterized by abundant chert beds. In fact, most chert found within the Monterey Formation is in the middle member. Dibblee (1950), however, recognized only an upper and lower member in his mapping. For the purposes of this report, all bedrock outcrops of Monterey rocks containing abundant chert are mapped as middle Monterey. Excellent exposures of middle Monterey bedrock chert are found along the coast near Purisima Point, Lions Head, and Mussel Rock, and sporadically throughout the Casmalia Hills inland from the Point Sal-Lions Head area.

It must be emphasized that areas mapped on the topographic maps as middle Monterey bedrock do not necessarily represent continuous exposures of chert beds. The designation of middle Monterey bedrock on this figure means only that the chert-rich middle Monterey member underlies that area and that outcrops of chert can be found locally, depending on the degree of exposure.

Other Monterey Bedrock

Chert occurs in other portions of the Monterey Formation, although not to the extent that it does in the middle member. All areas of lower and upper Monterey rocks which may contain isolated chert beds or nodules are classified as other Monterey bedrock.

Terraces and Stream Beds

Terraces are bench-like deposits of clay, silt, sand, and larger size material deposited by the action of waves or streams. Regional uplift coupled with changing sea levels through time have produced a series of terrace deposits of different elevations in the study area.

Chert often occurs as clasts of varying size, shape, and concentration in terraces and stream beds within the study area. No distinction is made between chert found in terraces of differing ages because an accurate terrace stratigraphy does not exist in the area. Clasts are generally concentrated at the base of a terrace where it is in contact with older deposits or bedrock. Therefore, terrace surfaces are usually barren of chert clasts and clasts are abundant only where streams, roads, or the sea have cut into a terrace exposing the lower terrace contact. One important exception to this occurrence is on the southern portion of Burton Mesa where chert clasts are found on the terrace surface. This surface has probably been eroded close to the bedrock contact (site of clast concentration), whereas the northern area of Burton Mesa has escaped this erosion. Stream beds may contain some chert clasts, especially in the Casmalia Hills. San Antonio Creek, Schuman Creek, and most of their tributaries are void of chert clasts.

Beaches

Beach chert clasts of variable size and shape are found almost exclusively near areas of Monterey Formation outcrop along the coast. Excellent deposits of such clasts are found at Purisima Point and Mussel Rock. Exposure of concentrated beach clast deposits may be seasonal, depending upon changing beach sand conditions. This effect was not considered during this study.

Chert clasts found on the beach, in terraces, or in stream beds may be equant, round, or tabular and are indistinguishable from one another. Surfaces of all clasts are usually somewhat rounded and often polished. Preservation of these surfaces on an artifact indicates a source either from the beach, stream, or terrace.

Franciscan Bedrock

Franciscan outcrops were only cursorily examined for chert content during the study. One exposure near the tip of Point Sal was examined; other potential sources of Franciscan chert are the Santa Ynez River bed and the Lospe Conglomerate Foundation. Franciscan chert can generally be distinguished from Monterey chert by its lack of lamination and distinctive colors (see below).

CHERT COLOR IDENTIFICATION

One main purpose of this study was to characterize color trends among chert outcrops in order to aid in the sourcing of lithic artifacts. Color variability and the presence of unusual lamination patterns or distinctive cortex material in outcrop was emphasized during sample collection; however, only color proved to be distinctive. The tremendous variation in lamination patterns and cortex material which occurs laterally along beds and locally between beds precludes these characteristics from being distinctive. One exception is where rounded and/or polished cortical surfaces are present on artifacts. In this case, the source was either a beach, terrace, or stream clast.

An overall pattern of color distribution exists that is related to outcrop type and locality. All chert outcrops are grouped into one of five distinctive color categories: very black, yellow-red laminated, gray-blue-brown, Franciscan colors, and other.

The spatial distribution of these color categories is presented in the topographic maps on file at UCSB by means of letter symbols superimposed on outcrop type. Close examination of the distribution of color yields useful information for artifact sourcing. These relationships and a description of color categories are discussed below.

Very Black

Cursory examination of the collection suggests that 80 to 90 percent of the lithic artifacts are made from very black chert. Very black chert occurs in a variety of outcrop types and can be identified on the basis of color alone. These outcrops may contain various quantities of other chert colors, especially white or tan and a small amount of gray and brown; however, very black usually dominates. Very black chert often contains small blebs and stringers of white, punky material (zebra striped chert) which is not distinctive to a particular outcrop. Sample No. 126 is a representative sample of very black chert.

Very black chert is abundant only in coastal outcrops, especially near Purisima Point, Lions Head, and Mussel Rock (middle Monterey bedrock, beaches, and terraces exposed along coast) where it is the overwhelming color present. It is also found in very minor quantities inland at several locations: sporadically in other Monterey bedrock, in several terrace localities, and in a road cut of middle Monterey along Brown Road (east of Point Sal). Therefore, when examining lithic artifacts composed of black chert, a very high probability exists that the chert derived from coastal outcrops. Other factors (see Exploitation Potential below) may help pinpoint the exact source.

Yellow-Red Laminated

Chert from the Burton Mesa Terrace outcrops is often brightly colored in shades of yellow, orange and red. These colors are unusual for Monterey chert and derive from weathering or staining of originally darker chert. This alteration is dramatically evident upon examination of the interiors of larger clasts which often retain some of the original color. Some red color invariably remains in these interior areas so that any artifact made from such a clast is not likely to be confused with darker chert found elsewhere.

This chert color type is restricted to Burton Mesa and is best exposed near the southern margin of this terrace (see Sample No. 100).

Gray-Blue-Brown

This category applies mainly to middle Monterey bedrock exposures found inland and, to a much lesser degree, to terrace outcrops near these bedrock exposures. This color category is broad but can be characterized by abundance of various shades of gray, blue-gray, brown, brown-red, and lesser quantities of tan, beige or other light colors (see Sample No. 124). Implicit in the application of this color category to an area is the absence of any very black chert. Although small quantities of the above listed colors may be found at coastal outcrops dominated by very black chert, no very black chert is found in the inland outcrops of gray-blue-brown. Therefore, artifacts may be made from gray-blue-brown chert have very high probabilities of originating at inland outcrops.

Franciscan Color

Franciscan chert from the area typically has a brick red color, as exemplified by outcrops near the tip of Point Sal (see Sample No. 127). Blue non-laminated chert is commonly found elsewhere in the Franciscan Formation (Woodring and Bramlette 1950; Dibblee 1950); however, no other outcrops were examined during this study.

Other

Outcrops which do not contain any of the previously grouped colors are designated as other. These colors are likely to be found in minor quantities at any given outcrop and are therefore not diagnostic as to source location.

EXPLOITATION POTENTIAL

In order to evaluate the manufacturing qualities of chert and the ability of any area to yield raw chert, it was necessary to devise an index which would rate effectively the suitability of any outcrop for tool manufacture. This would provide a basis from which to compare the quarrying characteristics of various chert localities and therefore aid in estimating the probability that stone from any particular outcrop was used for tool manufacture. This index, the Exploitation Potential, is based on four variables which were measured in the field: size of chert beds or clasts, fracture spacing, concentration or amount of material available, and difficulty of extraction. Each variable is rated numerically; the sum of these numbers is the Exploitation Potential (EP). Outcrops are considered potential chert sources on the following basis: EP No. 11 = excellent, EP No. 9 to 10 = good, EP No. 8 = fair, EP No. 4 to 7 = poor. A discussion of the four variable rating system is provided below, and the results are shown on the topographic maps and in Table 8-1. The glassiness of the chert in the variety sources is not considered in deriving this index because it is essentially constant in all Monterey chert in the area. Chert "quality" in this report therefore refers to size and fracture spacing.

Size

The size of clasts or the thickness of beds at an outcrop influence the potential usefulness of that outcrop for tool manufacture. Thicker beds and larger clasts provide more raw chert from which to choose and obviously allow manufacture of larger implements. The following criteria were used to evaluate the size variable:

3 = clasts greater than 15 cm greatest dimension
beds greater than 15 cm thick

2 = clasts less than 15 cm, greater than 7 cm greatest dimension
beds less than 15 cm, greater than 7 cm thick

1 = clasts less than 7 cm greatest dimension
    beds less than 7 cm thick

Fracture Density

The spacing of fractures in any raw chert influences the size of pieces that can be extracted and the likelihood that the artifact will break during manufacture. Fractures spaced farther apart are more desirable than those then are more closely spaced. The rating system is as follows:

3 = unfractured pieces greater than 10 cm greatest dimension

2 = unfractured pieces less than 10 cm greater than 4 cm greatest dimension

1 = unfractured pieces less than 4 cm greatest dimension

Concentration

This variable assesses the predictability of finding chert at any locality. For example, there is a much lower probability of finding (and much more energy must be expended in looking for) chert clasts in a terrace where they are widely dispersed than in a terrace where clasts are concentrated. Similarly, middle Monterey bedrock outcrops contain more chert beds than do other Monterey bedrock outcrops. Middle Monterey outcrops therefore receive a higher concentration number. Experience has shown that middle Monterey bedrock outcrops and clast deposits with clasts covering more than 25 percent of the surface have similar quantities of chert. A similar relationship exists between other Monterey bedrock outcrops and clast deposits with less than 2 percent clasts per square meter. Thus, clast deposits and bedrock exposures can be compared. Concentration is rated as follows:

3 = middle Monterey bedrock
    concentrated clast deposits with greater than 25 percent clasts/m^2

2 = clast deposits with less than 25 percent greater than 2 percent clasts/m^2

1 = other Monterey bedrock
    Franciscan Chert
    clasts with less than 2 percent clasts/m^2

Difficulty of Extraction

This variable rates the actual quarrying difficulty at a particular outcrop. It is assumed, for example, that beach cobbles are easier to quarry than middle Monterey bedrock exposures having a hard cortex that must be chipped away to extract usable chert. Only two numbers are used to assess this variable.

2 = surface cobbles
soft cortex bedrock

1 = hard cortex bedrock

CONCLUSIONS

The large number of potential chert source areas and the variability of chert in outcrops preclude an exact source determination for cherts used to manufacture artifacts found in the study area. However, chert locations, color patterns, and exploitation potential provide useful criteria for determination of probable chert source localities. The following summary is useful in this regard.

1. Chert within the study area is found in only five outcrop types. These are: middle Monterey bedrock, other Monterey bedrock, terraces and streambeds, beaches, and Franciscan bedrock.

2. Chert colors are not diagnostic of a specific source, but rather of general areas, as described below.

    - Very black - generally found along the coast in middle Monterey bedrock, beaches, and terraces and streambeds; also in small isolated localities inland.

    - Yellow-red laminated - found on Burton Mesa terrace exposures.

    - Gray-blue-brown - found principally in middle Monterey bedrock exposures inland from Lions Head and also in nearby terraces.

    - Franciscan color - known to occur in the vicinity of Point Sal.

    - Other colors - found at most outcrops and are not distinctive to any general area.

3. Lamination patterns in chert are not distinctive of specific outcrops.

4. Cortex material on artifacts is not distinctive for sourcing except where rounded and/or polished cortical surfaces are found preserved. These surfaces indicated either a beach, terrace, or stream, rather than a bedrock, source for the artifact.

5. Exploitation potential of the various chert outcrops was rated and mapped. The results of this work show:

- The areas where chert is best suited to tool manufacture are Mussel Rock and the area near Purisima Point. Thick, unfractured beds and abundant beach clasts of excellent quality make these areas the prime quarrying localities.

- Inland outcrops of middle Monterey bedrock are locally quite good. It must be borne in mind that these outcrops occur only at specific locations and not continuously over the area mapped.

- Upper Monterey bedrock and Franciscan rocks are generally poor sources of chert.

- Terrace outcrops are poor sources for raw material because of low concentrations of clasts and the poor quality chert commonly found in these outcrops. Exceptions to this trend are the terraces located several kilometers southeast of Lions Head and at seacliff exposures near Purisima Point and Mussel Rock.

Chapter 9

ANALYSIS OF COLLECTIONS

ANALYSIS OF CHIPPED STONE ARTIFACTS

Research Design and Analytic Approach

Research Design: The research program formulated for this region focuses on four aspects of hunter/gatherer behavior: optimal resource exploitation, optimal site location, resource scheduling, and maintenance and processing. These four topics are to be investigated under the assumptions of, respectively, optimal foraging theory, Wilmsens' (1973) model of hunter/gatherer location based on resource predictability, Flannery's (1968) predictions of responses to resource scheduling, and Binford's (1980) discussion of support activities with respect to basic subsistence/settlement strategies (Moore 1982:4-16). Examination of these topics requires both detailed environmental and archaeological information (Moore and Snethkamp 1982).

The general theories can be integrated into an overall set of expectations about hunter/gatherer behavior which can be tested against the archaeological record. The most basic of these expectations is that "land-use strategies among hunter/gatherer populations are largely structured by the diversity, location, and availability of resources" (Snethkamp 1981:23). Optimal foraging theory, essentially a set of least-effort assumptions balancing nutritional needs and resource procurement cost, is assumed to accurately predict the set of resources exploited prehistorically on the south coast. The distribution of these resources then conditions settlement types and locations: mobile and/or unpredictable resources are best exploited by relatively large groups in fairly sedentary, centrally located camps, while immobile, predictable resources are best exploited by small, dispersed groups in temporary camps (Wilmsen 1973). This dichotomy can be linked to Binford's characterizations of basic subsistence/settlement organization along a continuum from "foragers" to "collectors," with foragers such as the ethnographically known African !Kung San (Lee 1979) moving social groups to resources, and collectors such as the Alaskan Nunamuit Eskimo (Binford 1978) using small task groups to move resources to social groups. Binford relates these different organizations to variation in the productivity, distribution, and seasonal availability of important resources.

Ethnohistoric information clearly shows that most Chumash, the historic period inhabitants of the central California coast, were "collectors" in Binford's terms; that is, they lived in permanent or nearly permanent villages from which small task-groups went out to collect various resources for the larger social entity (see C. King 1971; Spanne 1975a; Tainter 1975). The development of this known organization, however, is poorly understood. It is generally thought that the Chumash subsistence/settlement pattern evolved out of an earlier one based on small, dispersed residential units (Landberg 1965; Spanne 1975a), essentially a foraging-type strategy.

The research design for the San Antonio Terrace, then, proposes a shift in regional subsistence/settlement strategies through time, from an early foraging pattern to a later collecting pattern, which should be understandable in terms of optimal diet and locational strategies as they respond to environmental change.

The analysis of chipped stone artifacts articulates with this research design in several places, primarily in the study of site location and of maintenance and processing activities. Both optimal foraging theory and resource scheduling must be tested by examining food remains in relation to environmental potential (Moore 1982:18-22, 24-26), rather than by examining collections of stone tools. As discussed in the research design (Moore and Snethkamp 1982:13-16), the reasons for locating a site vary with the type of site in question, and an accurate site typology is therefore necessary. Reconstruction of the activities carried out at a site is essential to such a typology, and is a research area for which chipped stone artifacts are particularly well-suited.

Binford (1980) proposes a basic site typology which is linked to the foraging/collecting continuum. In using this typology, we can distinguish broadly between activities involved in extraction (i.e., hunting), maintenance (i.e., tool repair), manufacture, and processing (i.e., cooking). Binford's site types include residential bases, locations, field camps, stations, and caches. Residential bases are the major occupation sites of any group; locations are sites where specific resources are procured but no other activities occur; field camps are temporary living areas for task groups who are away from a larger group for an extended period; stations are information-gathering sites such as hunting stands; and caches are storage sites. Foraging groups produce only residential bases and locations; a collecting strategy produces field camps, stations, and caches in addition to these (Binford 1980:9-12).

These types can be recognized by the varying combinations of manufacture, maintenance, processing and extraction carried out to them. Table 9-1 shows the expected distribution of general activities at the five types of sites just defined.

Only residential bases and field camps cannot be distinguished by the general kinds of activities carried out of them. They differ from one another in the wider range of maintenance, processing, and manufacturing carried out

Table 9-1. Activities Associated With Basic Site Types.

Site Type	Maintenance	Processing	Extraction	Manufacture
Residential base	+	+	-	+
Location	-	-	+	-
Field Camp	+	+	-	+
Station	+	-	-	+
Cache	-	-	-	-

in a residential base. In a field camp these activities will be linked to the resource to be exploited from the camp and not to the full set of a society's needs.

In addition to simply specifying the tasks performed in the sites on the terrace, this analysis will examine the technology in relation to quarry access, raw material limitations, and activity organization. The general framework within which tasks were performed can provide additional clues to the role of the study area in the larger region as well as further evidence for the organization of the larger subsistence/settlement system over time.

Analysis of the chipped stone artifacts from the San Antonio Terrace is therefore oriented towards reconstructing the specific activities carried out there, along with the organization of those activities, in order to classify accurately the sites into the five types just discussed. The general nature of the prehistoric occupation of the terrace can then be examined with reference to the research design discussed above. However, this study cannot necessarily provide a test of the overall model of subsistence/settlement change because the area considered here is only a small part of the region within which the predicted changes should have occurred. The region to which the research design refers includes Vandenberg Air Force Base and its immediate surroundings; the San Antonio Terrace is a small, environmentally distinct portion of this region. Therefore, changes in human use of the terrace through time can be taken as a reflection of regional changes, but lack of change may only reflect constant exploitation of a limited range of resources within a small area.

This study is also intended to illustrate the information potential of chipped stone artifacts. These artifacts not only are one of the most abundant classes of archaeological remains known, but were also the technological basis for the adaptive strategies used by the prehistoric people who made them. Considering this, we should see that detailed and sophisticated analyses of stone tools and their manufacturing debris are powerful sources of archaeological information.

However, this potential is generally not fully exploited. Most lithic studies tend to be descriptive rather than analytic, defining patterns for which no explanation in a larger behavioral framework is offered. In addition, until recently, functional studies have been haphazardly conceived and carried out; such results as they have produced have rarely been integrated with manufacturing information to produce even reasonably comprehensive pictures of particular technological patterns.

The potential of lithic analysis of showing us the basic adaptive pattern of a culture is largely untapped. This is particularly true in coastal California, where detailed lithic analysis is extremely rare. Comprehensive functional and technological studies can provide insights into prehistoric activity structure and hence social organization; site function and hence subsistence/settlement patterns; and raw material use and hence group mobility and regional economic organization, among other topics. The present study thus has two distinct goals: 1) to use information derived from a collection of chipped stone to infer land-use and other patterns in a specific area of coastal California, and 2) to provide an example of the methods which can be used to begin to exploit the information potential of an important class of material culture.

This present analysis will concentrate on three key areas: the definition of the tasks carried out on the San Antonio Terrace, procurement practices as reflected in the raw materials used for tool manufacture on the terrace, and the kind(s) of tool manufacture carried out there. The first provides information on why people were using the study area, the second helps to link those people into a wider regional settlement pattern based on the distribution of resources, and the third, in conjunction with the other two, helps to define the organization of their activities.

Analytic Approach: The goal of this study is to reconstruct patterns of prehistoric land-use and resource exploitation on the San Antonio Terrace through detailed analysis of chipped stone artifacts. Two general problems must be addressed to accomplish these goals: we need to understand the range of maintenance, processing, extraction, and manufacturing activities carried out in the area, and we need to understand the ways in which the technological requirements of those activities were satisfied.

Direct evidence of activities undertaken on the San Antonio Terrace is available on the used edges of tools recovered there. High power microscopic examination of tool edges allows the analyst to reconstruct accurately their uses and thus identify the activities carried out at a site (Keeley 1980). Microscopic use traces are also preserved on the platforms of resharpening flakes; examination of such traces provides information on tools used but not discarded at a site (see Frison 1968).

In combination with strictly functional information, data on manufacturing strategies helps to illuminate the technological requirements of different activities. Knowing what types of chipped stone artifacts were manufactured in the dunes and the ways they were manufactured can tell us much about the nature of land-use patterns there. Particularly, the absence of debris

from manufacturing certain kinds of tools or the absence of certain stages in tool manufacture can provide important clues to activity organization. Manufacturing procedures are also strongly affected by the availability and quality of raw materials; examining the use of different varieties of chert for different purposes is relevant to this question as well.

This study then relies primarily on high-power microscopic analysis (HPMA) of the edges of a sample of the chipped stone artifacts from the study area to infer specific tool functions. Technological information and information on chert source utilization were also gathered and integrated with functional interpretations.

Approaches to Inferring Tool Function: Functional information can be obtained from a variety of sources, including tool morphology, retouch patterns, and use-wear traces (e.g., Keeley 1980; Tringham et al. 1974; Semenov 1964; Ahler 1970). However, not all of these sources supply the analyst with comparable types of data. In particular, there is a fundamental dichotomy between morphological information and information on wear patterns derived through HPMA. In general, morphological studies, including analysis of edge angles, shapes, and overall form and type of retouch, can only define general limits on the type of use to which the artifact could be put. In contrast, HPM wear pattern analysis examines the use to which an artifact was actually put. Edge angles, for instance, can define tools which are theoretically best suited to scraping and cutting, but can neither tell us whether an edge actually was used, nor how or on what material it was used. Specific functional interpretations, then, must be grounded on microwear analysis.

Integration of microwear and morphological data not only provides a potential basis for inferring the specific functions of highly weathered tools, but also provides insights into overall patterns of tool curation and use, and hence into activity organization. This study includes a series of attributes which reflect the suitability of an artifact, first, for use in general, and second, for different types of more specific uses. Attributes of size, including length, width, mass, and thickness, relate to the ease with which an artifact can be manipulated and the likelihood that it will break. Characteristics of the edge can outline the general sorts of use the artifact might be best suited for. Variations in edge angle have been linked to a dichotomy between scrapers and cutting tools (Wilmsen 1968), a relationship that has been partially supported by Keeley's work (1980:110-111). Edge shape (or configuration) is also directly relevant to the kinds of tasks a tool can be used for. The presence and type of retouch on a tool can also provide information on resharpening patterns and the existence of formulized tool types.

Three types of use wear traces have been recognized: edge damage, striae, and polishes. Although both edge damage and striae are 1) not highly sensitive to differences in specific worked materials, and 2) created by a variety of factors other than use, they are a valuable source of information in combination with information on microwear polishes.

There are two major problems with reliance on edge damage (at magnifications below 60x) as a sole source of information. These are 1) that edge damage is affected by a variety of factors which are not directly relevant to specific uses and which can result both in identical wear patterns from different uses and different wear patterns from identical uses, and 2) that a variety of natural and cultural processes create edge damage on artifacts which is indistinguishable from that created during use. Among the factors controlling edge damage formation are edge angle, angle of attack, the amount of force applied, the brittleness of the stone from which the tool is made, the tool-user's ability to avoid fracturing the edge, the length of time the tool was used, the mode of use of the tool (for example, scraping or cutting) and the material on which the tool was used.

The variety of technological and natural processes which can create edge damage on an artifact is enormous. Intentional retouch creates tiny scars which cannot be distinguished from those caused by use. Spontaneous retouch (Newcomer 1976), caused when a flake rotates against the core from which it is struck, can mimic morphological types as well as use damage. The difficulties in interpreting traces left by grinding biface edges to facilitate flake removal have been clearly demonstrated by the response to Nance's (1971) attempt to demonstrate that Stockton points were actually used as knives (see Hester and Heizer 1973; Keeley 1974a; Sheets 1973). Natural sources of edge damage include trampling (Flenniken and Haggarty 1979) and soil movement (Keeley 1980:30-35). In studying a Lower Paleolithic collection subjected to soil movement, Keeley (1980:165) documented the potential discrepancy between analyses based only on edge damage and those based on more sophisticated methods: an edge damage analyst interpreted as used 95 percent of the collection, mainly fragile biface thinning flakes, while observations of polishes indicated that the rate was closer to 9 percent.

Traces observable at higher magnifications provide more explicit functional information. Keeley (1980:35-61) has described different polishes which distinguish a variety of worked materials, including wood, bone and antler, dry hide, fresh hide, meat, and plants. In addition to these, working shell leaves its own distinctive polish (Keeley, personal communication). Anderson (1981) has demonstrated that distinct physical processes cause the visible differences in wood, bone, and plant polishes; however, sources of observed variability in other types of polish are presently unclear. Keeley (1980:25-35) has also examined the microscopic effects of a wide variety of technological and natural processes, such as hammerstone abrasion and soil movement, and has found that they clearly differ from use polishes in both their appearance and distribution on the tool. Variability in polish appearance is therefore clearly linked solely and directly to variability in specific tool uses. Independent experimental work by microwear analysts working with tools made from a variety of different types of stone from England, France, Greece, Texas, Illinois, and elsewhere (briefly summarized by Keeley 1981:349) have shown that the appearance of the various microwear polishes does not vary among microcrystalline silicates

(i.e., flint, chert, agate, jasper, etc.). This has been further confirmed by experiments by this author and others with tools made from Monterey chert collected from Vandenberg Air Force Base.

Polish analysis, however, is best suited to determinations of specific worked material, although the distribution of polish on an edge can also illuminate the way in which a tool was used. Once the used portion of a tool has been defined on the basis of polish distribution, edge damage and striation patterns can provide additional important information. Both of these types of traces, particularly striation patterns, are well-suited to interpretations of the mode of tool use (for example, scraping or cutting). Edge damage can also provide critical information on specific uses. For instance, the difference between butchering knives and meat-cutting knives is basically the presence of extensive edge damage caused by brief contact with bone and tough ligaments while cutting up an animal on an edge showing only meat polish.

Reliance on polish analysis not only prevents one from mistaking backing on a tool intended to protect the user's hand for damage caused by use, but allows confident, experimentally verifiable interpretations of specific tool uses which can form the basis for accurate and productive reconstructions of prehistoric behavior. Both natural and technological effects have been experimentally determined to leave distinct high magnification traces which differ from use polishes both in their appearance and distribution on the tool (Keeley 1980:25-35); this distinction cannot be made using any other approach to functional analysis. A complete program of microwear analysis collects information on all varieties of use traces and integrates them into specific, reliable interpretations (Keeley 1974, 1980:8-9, 176). The reliability of these interpretations, however, is based ultimately on examination of microwear polishes.

This emphasis on functional interpretations leads to a slightly unusual use of terminology. For this report, the usages of three important terms are as follows:

- Artifact: Any object manufactured or modified by man. As the study collection contains nothing but artifacts in this sense, in this report the term is essentially synonymous with "object."

- Tool: Any artifact showing microscopic traces of use. This usage has absolutely nothing to do with formal typology or presence of retouch, and includes used flakes as well as more traditionally recognized forms.

- Flake: Any piece of chipped stone detritus showing no post-manufacturing modifications other than those caused incidentally during use. A flake may have use-wear on its edges and hence be classed as a "tool," or may be unworn and hence classed as "unused" or "debitage."

The importance to the present study of making accurate functional interpretations requires a sophisticated approach to studying tool use. HPMA is the most accurate such approach available at present. Reliance on it is the cornerstone of this study.

Sampling Strategies And Methodology

A flexible sampling program structured around the analysis of flake size by site was employed during this analysis. The decision to sample within size categories was based on two major factors. The variety of screen sizes used during the initial processing of material from different sites made it necessary to standardize these data. As a result the artifacts were arbitrarily sized according to field screen sizes (1/16 inch, 1/8 inch, and 1/4 inch). A category of 1/2 inch and larger was also added.

Sampling within these size categories took two critical factors into account. The first is the varying information potential of different size flakes. Extremely small flakes tend to have a low information potential for several reasons. First, they are difficult to manipulate during analysis, resulting in lack of precision in many measurements made on them. Second, many small flakes are not intentionally struck, but rather come off as shatter between a larger flake and the core or tool from which they were removed. Their detailed analysis would therefore introduce a large random element into this study. This low information potential is aggravated for the MX collection by the second factor, the fact that many of the small flakes recovered were not in primary context, but rather were blown in from some distance away. Because wind-blown flakes have nothing to do with the human activities carried out on the sites at which they were found, their analysis would provide no insights into those activities.

The specific sampling fractions chosen for different size categories reflect these two factors. These fractions differ from those originally proposed in the reduction in 1/8 inch platforms examined and the increase in 1/4 inch flakes examined for technological variables.

The study collection consists of 19,408 flakes and 141 other artifacts classified by CCP personnel as utilized flakes and retouched pieces. This collection was recovered from 25 sites on and adjacent to the San Antonio Terrace. Several general surveys also produced artifacts which could not be tied to specific sites.

All objects were subject to either 1) a general lot-by-lot analysis of selected variables, or 2) an intensive individual technological and functional analysis. All sites with a total chipped stone inventory of less than 100 artifacts as recorded on summary sheets provided by CCP personnel in spring 1982 were subject to only a lot-by-lot analysis, to ensure having enough detailed observations from each sampled site to allow comparisons. This criterion provides a population of 7,141 flakes from 10 sites from which to sample. Final site-by-site totals were not available until the sample had been partially drawn, and because of a discrepancy between the initial and final counts for SBa-1037 (with a final total of 151 flakes) it was not sampled.

Flakes from sites SBa-1170, SBa-1173, SBa-1176, and SBa-1193 were not subjected to detailed individual analysis after the initial sort indicated that the majority of them (over 90 percent) were heavily wind polished. A lot-by-lot analysis was completed for these sites. Specific variables used for the analysis are given below.

Analytic Variables: Technological attributes were measured on a sample of flakes drawn by size class on a site-by-site basis, as well as on all artifacts recorded by CCP as tools as previously discussed. The following attributes were recorded. A full set of artifact codes is presented in Table 9-2.

- Presence and type of cortex: Frequent cortex in a collection can indicate early stages of core reductions. A distinction was made between relatively fresh shale cortex, indicating a bedrock source, and battered cobble cortex.

- Fragment type: Systematic breakage patterns can be diagnostic of specific reduction strategies and stages of manufacture (see Frison and Bradley 1981; Tunnel 1977). Fragment types were classified as longitudinally split, distal, midsection, or proximal fragments, or combinations of split and other types.

- Orientation of dorsal scars: The angle of a flake's dorsal scars relative to the direction in which it was struck can provide information about reduction strategies. Late stages in biface manufacture, for instance, generally show frequent removals parallel to previous removals, while less systematic strategies may show more variety (see Bamforth 1981). This can be measured with polar graph paper, placing the axis along which the flake was struck at zero degrees and extending the lines made by the dorsal scars onto the paper to read angle measurements.

- Platform type: The nature of the platform is useful in constructing manufacturing sequences and in distinguishing manufacture from resharpening flakes. Distinctive platforms are produced on flakes removed from bifaces, several types of unifaces, and unmodified flakes (Frison 1968; Shafer 1970): bifacial flakes show remnant scars on both the platform and the face opposite it, unifacial flakes show scars on only one or the other, an unmodified platforms show scars on neither.

- Cortex on platform: This is generally found on flakes removed in early stages of manufacture. The same types of cortex were recorded as in the first variable, above.

Table 9-2. Variable Codes

1. Material:
   1. very black
   2. yellow/red laminated
   3. gray-blue-brown
   4. Franciscan
   5. other chert
   6. fused shale
   7. obsidian
   8. other

2. Cortex:
   1. absent
   2. bedrock
   3. cobble

3. Wind Polish:
   1. not polished
   2. slightly polished
   3. moderately polished
   4. severely polished
   5. flake scars obliterated

4. Edge Rounding:
   1. not rounded
   2. slightly rounded
   3. severely rounded

5. Fragment Type:
   1. proximal
   2. midsection
   3. distal
   4. split
   5. split/proximal
   6. split/midsection
   7. split/distal
   8. indeterminate
   9. complete

6. Platform Type:
   1. absent
   2. unifacial/dorasal
   3. unifacial/ventral
   4. bifacial
   5. unmodified
   6. uncertain
   7. potlid

7. Cortex on Platform:
   1. absent
   2. bedrock
   3. cobble

8. Use-wear on Platform
   a. mode of use
      0. unused
      1. cutting
      2. scraping
      3. shell
      4. meat only
      5. butchering
      6. unknown
      7. skinning
      8. projectile point

   b. worked material
      0. unused
      1. wood
      2. plants
      3. bone/antler
      4. fresh hide
      5. dry hide
      6. shell
      7. meat only
      8. butchering
      9. unknown

9. Type Edges:
   1. flake
   2. irregular biface
   3. preform
   4. uniface (end scraper)
   5. uniface (side scraper)
   6. core
   7. chunk
   8. broken cobble
   9. large leaf-shaped biface
   10. leaf-shaped point
   11. concave base point
   12. contracting stem point
   13. corner-notched point
   14. other biface
   15. untypable point
   16. notch
   17. burin spall
   18. other uniface
   19. possible bladelet core
   20. drill

10. Mode of Use:
    (see 8a)

11. Worked Material:
    (see 8b)

12. Used Edges:
    0. unused
    1. lateral
    2. both lateral
    3. distal
    4. indeterminate
    5. proximal

- Platform width from end to end and thickness from the dorsal to the ventral edge: The size of the striking platform can help to distinguish stages in manufacture and to distinguish the products of different manufacturing sequences.

In addition to the technological variables just described, the following information was collected:

- Material type: Raw material type was recorded on the basis of color, as is discussed in Chapter 8.

- Wind polish/edge rounding: These two variables were recorded on a ranked scale on the basis of macroscopic examination.

- Size: Size was measured with maximum length parallel to the direction in which the flake was struck, maximum width perpendicular to the length, and maximum thickness.

- Edge: The length of the working edge was measured by defining the ends of the used portion by the presence of use-wear traces and measuring a straight line between them.

- Shape: Edge shape was quantified by measuring the greatest distance from the line drawn to measure edge length and the actual edge of the tool. Convex edges have a positive value for this variable; concave edges are negative.

- Wear patterns: Three types of use-wear traces were recorded: polish, edge damage, and straie. Polish and edge damage classifications follow Keeley (1980:24-25, 35-61). The following polishes were recorded when present: meat, fresh hide, dry hide, wood, bone/antler, shell, and plant. Striae were noted by their orientation on the edge. For all traces, the location on the tool and the face of the tool on which the trace was found were noted.

Provenience data was specific only to site; lot numbers gave access to more specific locational information in the very few cases in which it was useful.

These variables were chosen because of their expected relevance to the problems addressed in this analysis. While other choices could have been made, these appear to give the optimal balance between information return and economy.

Sampling Strategy: As indicated previously, the sampling program was structured according to flake size. The first step in the analysis was to separate all flakes by size category, including 1/16 inch to 1/8 inch, 1/8 inch to 1/4 inch, 1/4 inch to 1/2 inch, and larger than 1/2 inch. These size categories will be referred to as 1/16 inch, 1/18 inch, 1/4 inch, and 1/2 inch respectively for the balance of this report. The counts by size category by site are given in Table 9-3.

After the flakes were sorted by size, each category was sampled by site. To arrive at the exact number of flakes to be sampled, the total number of flakes in each size category by site was multiplied by the overall sample proportion. For example, if a 50 percent sample was required from a site with 143 1/4-inch flakes, 72 flakes would be selected. To remove the sample for each size category by site all flakes were laid on a table. Flakes were chosen by taking every "n"th unpolished flake. If a 50 percent sample were

Table 9-3. Counts of Flakes by Size.

Site	1/16 Inch	1/8 Inch	1/4 Inch	1/2 Inch	Total
SBa-704	0	18	16	20	54
SBa-706	199	872	402	149	1,622
SBa-980	113	1,342	569	231	2,255
SBa-998	7	45	14	10	76
SBa-1036	96	423	135	54	708
SBa-1037	2	99	43	7	151
SBa-1038	7	450	109	34	600
SBa-1052	4	4	3	0	11
SBa-1066	3	7	4	1	15
SBa-1070	75	813	295	92	1,275
SBa-1070E	81	16	2	1	100
SBa-1153	1	0	1	0	2
SBa-1155	116	22	6	7	151
SBa-1170	42	680	286	69	1,077
SBa-1173	294	689	82	0	1,065
SBa-1174	103	102	73	29	307
SBa-1176	140	406	23	1	570
SBa-1177	1	2	5	3	11
SBa-1179	1,231	174	13	5	1,423
SBa-1180	39	47	3	0	89
SBa-1180S	0	5	7	21	33
SBa-1181	1	17	7	3	28
SBa-1193	2,109	2,597	1,120	67	5,893
SBa-1201	0	0	9	0	9
SBa-1546	0	6	4	0	10
SBa-1718	426	274	87	20	807
SBa-1730	0	36	16	8	60
non-site	192	478	251	85	1,006
TOTAL	5,282	9,624	3,585	917	19,408

required, every second flake would be selected; if a 20 percent sample was required every fifth flake was selected. If the flake to be selected was wind polished, the next unpolished flake was selected. No flakes with macroscopic wind polish were selected for analysis. There were enough unpolished flakes in all sites to remove the required sampling fraction.

Artifacts from ten sites and two general surveys were subject to intensive individual analysis. All artifacts not taken in the sample for intensive analysis were analyzed on a lot-by-lot basis by:

- size
- material type
- degree of wind polish
- degree of edge rounding
- presence and type of cortex

Degree of edge rounding and presence and type of cortex were not recorded for 1/16 inch flakes. Sampling considerations and variables recorded for each site by size category are given below. A summary of the sampling fractions and number of artifacts analyzed in each category for the sites subject to intensive analysis are given in Table 9-4.

1/16 Inch Flakes: All 1/16 inch flakes were sorted by lot for material and degree of wind polish. No further analysis was undertaken.

1/8 Inch Flakes: All of the 1/8 inch flakes were initially sorted into two categories: with and without platforms. Fifty percent of all flakes with platforms (156 flakes or approximately 3 percent of all 1/8 inch flakes) were subjected to intensive individual analysis (see Table 9-4). Six variables were recorded for each flake, including:

- degree of wind polish
- degree of edge rounding
- presence and type of cortex on dorsal face
- material type
- platform type
- presence and type of cortex on platform

A sample of these flakes was then examined under the microscope for evidence of microscopic use wear patterns on their platforms. No evidence of use wear was discovered on the first 24 flakes examined (Table 9-5). As a result, no further microscopic examination of 1/8 inch flake platform was undertaken.

The balance of the flakes with and without platforms that were not subject to intensive individual analysis were analyzed by lot. Variables recorded for each lot included:

- material type
- degree of wind polish
- degree of edge rounding
- presence and type of cortex

Table 9-4. Summary of Samples Sizes.

SIZE?	1/8 INCH			1/4 INCH				1/2 INCH			
PLATFORM?	ALL	YES		ALL	YES	NO		ALL	YES		NO
PERCENT?	100	50	8	100	60	60	10	100	100	30	50
ANALYSIS?	---	T,P	-P-	---	T,P	-T-	-E-	-T-	-P-	-E-	-E-
Site S9a-											
706	872	26	--	402	61	180	22	149	31	11	58
980	1342	60	11	569	200	250*	23	231	66	20	46
1036	423	21	--	135	28	75	7	54	19	5	29
1038	450	4*	4	109	18	51	4	34	4	3	4
1070	813	29	1	295	61	148	21	92	35	10	12
1070E	16	1	1	2	1	0	0	1	1	0	0
1155	22	0	--	6	1	0	0	7	1	0	1
1174	102	6	6	73	18	32	8	29	10	4	11
1179	174	2	2	13	5	3	0	5	1	0	5
1718	274	0*	--	87	18	36	0	20	4	0	0
ESS	59	1	--	10	0	4	0	9	2	0	2
F/O	124	6	--	91	0	37	0	47	12	0	15
TOTAL	4571	156	24	1792	411	816	85	678	172	53	183

T - Technical data recorded
P - Platforms examined microscopically
E - Edge examined microscopically
* - Sample incomplete

Table 9-5. Results of Microscopic Examination of Sample Flakes.

Platforms Examined:	Total	Total Showing Use
1/8 inch	24	0
1/4 inch	411	4
1/2 inch	172	0
overall percent showing use:		0.7
Edges Examined:		
1/4 inch, no platform	85	0
1/2 inch, no platform	185	11
1/2 inch, with platform	53	6
overall percent showing use:		5.3

In general, the large number of wind polished 1/8 inch flakes and number of flakes without platforms limited the scope of the analysis.

The data collected in this portion of the program proved to be of very little use in the analysis. An extremely high percentage of 1/8 inch flakes are apparently shatter produced when larger flakes were struck, and therefore provide virtually no functional or technological information.

1/4 Inch Flakes: All of the 1/4 inch flakes (1792 flakes) were initially sorted into two categories: with and without platforms. Sixty-eight point five percent of the flakes in both categories (1,227 flakes; see Table 9-5), including 411 with platforms and 816 without platforms, were individually analyzed and the following variables recorded:

- material type
- degree of wind polish
- degree of edge rounding
- length in direction that flake was struck
- maximum thickness
- mass
- presence and type of cortex
- fragment type
- orientation of dorsal scars
- maximum width perpendicular to the length
- platform type (if applicable)
- platform cortex (if applicable)

All of the 1/4 inch flakes with platforms which were examined for technological variables were also examined under the microscope for evidence of use wear on their platforms. In addition, approximately 10 percent of all 1/4 inch flakes without platforms (85 flakes) were microscopically examined for evidence of use wear along their edges. Four of the platforms and none of the edges without platforms sampled showed evidence of microscopic use wear.

The remaining forty percent of the flakes were analyzed on a lot-by-lot basis for:

- material type
- degree of wind polish
- degree of edge rounding
- presence and type of cortex

These data proved to be extremely useful in the analysis which follows. The only variables which were not used are maximum length and mass; these could have been eliminated from the study with no loss of information. The technological variables in particular proved to be excellent indicators of manufacturing patterns.

1/2 Inch Flakes: One hundred percent of the 1/2 inch flakes (678 flakes) were subjected to intensive individual analysis after they were sorted into the two basic categories: with and without platform. Analytical variables recorded for all of the 1/2 inch flakes included:

- material type
- degree of wind polish
- degree of edge rounding
- length in direction that flake was struck
- maximum thickness
- mass
- presence and type of cortex
- fragment type
- orientation of dorsal scars
- maximum width perpendicular to the length
- platform type (if applicable)
- platform cortex (if applicable)

One hundred percent of the 1/2 inch flakes with platform (172 flakes) were examined under the microscope for evidence of use wear on the platforms. No use wear polishes were identified on any of these platforms (see Table 9-5). An additional 30 percent of the flakes with platforms, or 53 flakes, were examined for evidence of use wear on their edges. Six of the 53 flakes showed wear traces.

In addition, 183 flakes without platforms, or 50 percent of all 1/2 inch flakes without platforms, were microscopically examined for evidence of use wear along their edges. Eleven of these flakes showed evidence of use.

As in the case of the 1/4 inch flakes, these data were very important to the analysis. One-half inch flakes particularly appear to be excellent sources of technological information, probably because they are less likely to include accidentally produced debris that adds noise to the analysis.

Microscopic Examination: High power microscopic examination of the study collection was carried out using an Olympus BHM binocular, incident-light microscope. Bamforth (1980) and Keeley (1980:12-14) explain in detail why this type of equipment is necessary for viewing microwear polishes.

In addition to the artifacts drawn for microscopic analysis under the sampling program presented above, 141 retouched and apparently used pieces which were individually wrapped and bagged by CCP personnel prior to the beginning of this analysis were also examined under the microscope. All of this material was cleaned before examination, following procedures outlined by Keeley (1980:10-11). The artifacts were first cleaned with a non-abrasive detergent in an ultrasonic cleaner and then soaked in a 10 percent solution of HCl for approximately 10 minutes prior to examination. Immersion in NaOH to remove organics was not considered necessary, as none were seen on the tools either macro- or microscopically. NaOH has no effect on polish appearance. The artifacts were then scanned at 100x to locate polishes, which were identified along with striae at 200x. Edge damage was examined at 50x using the same microscope. Polishes were identified by comparison with those in a collection of over 100 experimentally worn tools at UCSB. These tools include a number made of local Vandenberg cherts as well as other made of Texas cherts and agate; as was noted earlier, the appearance of polish on these different types of stone is identical.

The combined results of these various sources of information forms the basis for the remainder of this analysis. The diversity of information recorded should provide independent lines of evidence which are relevant to the problems discussed and which can be evaluated against one another in interpreting patterns.

Post-Depositional Process

In the context of this study, the major post-depositional process at work in the San Antonio Terrace is the movement and alteration of chipped stone artifacts by the wind. Alteration takes the form of severe edge rounding and the development of a frequently macroscopic polish over an artifact's entire

surface, caused by sand abrasion. Abrasion may result when very small artifacts blow with the sand and skip over the dunes. Moderately sized artifacts roll as the sand around them blows away, and they and the largest classes of artifact are polished in place by blowing sand (see Chapter 5). This polish completely obscures both microwear polishes and striation patterns, although it does not resemble any kind of use trace.

This implies that artifact size is an important variable in determining the condition of the artifacts, even though there is no systematic difference between the kinds of weathering present on artifacts of different sizes. It is also clear that many of the smallest artifacts from the study area have been blown some distance from the point where they were discarded to the point where they were recovered. This section does not present a detailed analysis of these problems; that topic is discussed in Chapter 5. Rather, it evaluates the effect of these processes on the analysis presented in succeeding sections.

Table 9-6 presents counts of flakes larger than 1/16 inch from each site by size and degree of polish. Degree of polish was evaluated macroscopically on a ranked scale from unpolished to severely polished. Flakes which appeared to be completely fresh, whose surface showed no evidence of any alteration, were classified as "unpolished." At the other extreme, flakes whose surface showed a sheen similar to that seen on glazed pottery were classed as "severely polished." Intermediate degrees of polish ("slightly polished" and "moderately polished") represent roughly equal increments in the development of wind polish between these two extremes. Consistency in making this evaluation was maintained by having one individual evaluate it for all flakes. There is obviously considerable variability between and within the sites in this table. This variability is the result of two factors: flake size and site location. Tables 9-7 and 9-8 show, respectively, degree of polish for different flake sizes and degree of polish for different flake sizes in intermediate dunes and other sites (see Activity Reconstruction section). Obviously, smaller flakes and flakes from sites in the intermediate dunes tend to be most highly wind-polished.

Although these conclusions are important, they do not affect the following analysis for several reasons. First, the intensively analyzed sample drawn according to the guidelines discussed in the above section, Sampling Strategies and Methodologies, includes only unpolished flakes, essentially eliminating redeposited material. In addition, artifacts included in the analysis other than those taken in the sample, such as retouched pieces or flakes designated as used by CCP personnel, were uniformly in the largest size categories. This size of artifact, generally well over 1/2 inch in minimum dimension, is almost certainly too large to be transported by the wind. These artifacts are likely to be in more or less primary context; any wind-polish present is probably the result of on site sand blasting. The analysis which follows has thus been carried out on material chosen in such a way that problems of artifact movement and alteration due to post-depositional processes are minimized.

Table 9-6. Site by Site Frequency of Flakes by Degree of Wind Polish within Size Categories.

Site	Size	1	2	3	4	t
1036	1/2	54	0	0	0	54
	1/4	131	0	0	4	135
	1/8	414	9	0	0	423
1037	1/2	3	3	1	0	7
	1/4	9	20	6	5	43
	1/8	40	52	4	3	99
1038	1/2	34	0	0	0	34
	1/4	108	1	0	0	109
	1/8	90	231	122	7	450
1052	1/4	2	1	0	0	3
	1/8	3	3	0	0	6
1066	1/4	4	0	0	0	4
	1/8	5	2	0	0	7
1070	1/2	91	1	0	0	92
	1/4	295	0	0	0	295
	1/8	805	8	0	0	813
1070E	1/2	1	0	0	0	1
	1/4	2	0	0	0	2
	1/8	16	0	0	0	16
1155	1/2	7	0	0	0	7
	1/4	5	1	0	0	6
	1/8	6	11	5	0	22
1170	1/2	3	13	20	33	69
	1/4	16	22	54	194	286
	1/8	0	10	199	471	680
1073	1/2	0	0	0	0	0
	1/4	1	0	0	81	82
	1/8	0	0	0	689	689
1174	1/2	29	0	0	0	29
	1/4	73	0	0	0	73
	1/8	100	2	0	0	102
1176	1/2	1	0	0	0	1
	1/4	0	1	3	19	23
	1/8	9	6	12	379	406
1177	1/2	1	1	0	1	3
	1/4	2	0	0	3	5
	1/8	0	1	0	1	2
1179	1/2	5	0	0	0	5
	1/4	11	0	1	1	13
	1/8	32	43	70	29	174
1180	1/4	0	0	0	3	3
	1/8	9	0	0	38	47

Table 9-6. (Continued).

Site	Size	1	2	3	4	t
1180S	1/2	0	0	1	20	21
	1/4	0	0	1	6	7
	1/8	0	0	0	5	5
1181	1/2	2	1	0	0	3
	1/4	0	0	0	7	7
1546	1/8	0	0	0	17	17
1193	1/2	0	0	1	66	67
	1/4	8	10	22	1,088	1,120
	1/8	19	39	150	2,389	2,597
1201	1/4	0	0	0	9	9
1546	1/4	4	0	0	0	4
	1/8	5	1	0	0	6
1718	1/2	20	0	0	0	20
	1/4	86	0	1	0	87
	1/8	179	12	22	61	274
1730	1/2	8	0	0	0	8
	1/4	16	0	0	0	16
	1/8	28	8	0	0	36
704	1/2	3	4	13	0	20
	1/4	12	3	1	0	16
	1/8	18	0	0	0	18
706	1/2	149	0	0	0	149
	1/4	402	0	0	0	402
	1/8	870	1	1	0	872
980	1/2	231	0	0	0	231
	1/4	569	0	0	0	569
	1/8	1,312	7	1	22	1,342
998	1/2	8	2	0	0	10
	1/4	14	0	0	0	14
	1/8	43	0	1	1	45
Surface	1/2	28	6	40	11	85
	1/4	59	20	71	101	251
	1/8	152	7	44	275	478

1 - not polished
2 - slightly polished
3 - moderately polished
4 - severely polished
+ - total

Table 9-7. Degree of Wind Polish by Flake Size.

Size	None	Slight	POLISH Moderate	Severe	Total
1/2	676	31	75	130	912
1/4	1,828	77	159	1,520	3,584
1/8	4,154	461	630	4,385	8,118
TOTAL	6,658	569	864	6,035	14,126

Table 9-8. Degree of Wind Polish by Flake Size and Site Location.

Location	Size	None	Slight	POLISH Moderate	Severe	Total
terrace edge	1/2	594	7	14	0	615
	1/4	1,599	24	7	9	1,639
	1/8	3,649	310	128	32	4,119
central dunes	1/2	84	40	62	131	317
	1/4	230	55	153	1,512	1,950
	1/8	506	143	503	4,334	5,486
TOTAL		6,662	579	867	6,018	14,126

Chronology

Projectile points are the only known time-sensitive chipped stone artifacts on the central coast. Four types of chronologically meaningful points are present in the study collection--two large types (presumably dart points), and two small types (presumably arrow points) (M. Glassow, J. Johnson, personal communication). The former include corner notched and contracting stem points generally dated to the Middle Period (1400 B.C. to A.D. 1150); the latter include leaf-shaped and basally notched points, generally dated to the late period (A.D. 1150 to 1804). Only the small basally notched points have a clear chronological position, dating to the latest phases of the Late Period. Other considerations, however, suggest that simply using these point types to date sites to the Middle or Late Periods is incorrect.

The generally accepted date for the appearance in North America of small projectile points which probably mark the introduction of the bow and arrow is A.D. 500 (i.e., Frison 1978; Thomas 1981, 1983:174 also dates the Rosegate point series, the earliest small point types in the Great Basin, to this time). Given no other date for this introduction in California, and considering the unclear chronological position of all but the small basally notched points, this study tentatively considers sites containing dart points to date before A.D. 500, and those containing arrow points to date after A.D. 500. This dichotomy does not correspond to any division of the accepted bead-based local chronology (C. King 1981). Sites containing dart points will be referred to here as "early," and sites containing arrow points will be referred to here as "recent." These terms are used solely for convenience in this report with no intention of defining a new chronology. Geomorphological information indicates that no sites on the terrace apparently pre-date A.D. 1 (see Chapters 4 and 5).

The distribution of these points in the study area is shown in Table 9-9, and they are illustrated in Figures 9-1a through 9-1f, also by their distribution. Sixteen of the 25 sites containing other chipped stone artifacts can be dated by their associated points. The small number of points per site may be the result of limited excavation. However, only one point was recovered from SBa-1179, the only substantially excavated site in the sample. This suggests that a low number of points per site is normal in the study area.

When the points are grouped into early and recent types (because of small samples) the lack of multiple period occupations in the sample is striking: there are no sites with points from both periods. The probability of no overlap between nine recent and seven early components in 25 sites by the binomial theorem is .07 (p=.101, g=.899); considering only the 16 dated sites, the probability is .01 (p=.24, q=.76). Unfortunately, the small numbers of dated sites create large standard errors in the estimates of the population proportions from which p and q are derived. However, this fairly

Table 9-9. Chronologically Typable Points by Site.

	Early		Recent		
	Corner Notched	Contracting Stem	Small Leaf Shaped	Small Concave Base	Total
SBa-581	-	-	-	1	1
SBa-704	-	-	-	-	0
SBa-706	-	-	2	-	2
SBa-980	-	-	1	-	1
SBa-998	-	1	-	-	1
SBa-1036	-	-	-	-	0
SBa-1038	-	-	1	-	1
SBa-1070	-	-	2	-	2
SBa-1070E	-	-	1	-	1
SBa-1155	-	-	-	-	0
SBa-1170	-	1	-	-	1
SBa-1173	-	1	-	-	1
SBa-1174	1	1	-	-	2
SBa-1176	-	-	-	-	0
SBa-1177	-	-	3	1	4
SBa-1179	-	-	-	1	1
SBa-1180S	-	1	-	-	1
SBa-1181	-	-	1	-	1
SBa-1718		1	-	-	1
SBa-1728	-	1	-	-	1
non-site	-	1	2	-	3
TOTALS	1	8	13	3	25

extreme result tentatively suggests that the overall settlement pattern in the dunes is dispersed, and the specific locations within the area were not favored over others for reuse. This possibility is considered below in the context of the larger analysis.

Additional chronological information is available from three sources. A single Late Period bead found at SBa-1179 supports the recent date based on a single projectile point excavated there. Late period occupation is also indicated by radio carbon dates from SBa-706, -980, and -1179 (see Chapter 7). In addition, soil chemistry offers some chronological insights. Rockwell (Chapter 6) has studied soil color, acidity (pH), and calcium and phosphorus levels at 13 sites in the study area, nine of which can be dated through associated projectile points. Young soils are light colored; they become darker with age and midden development. Calcium is introduced into

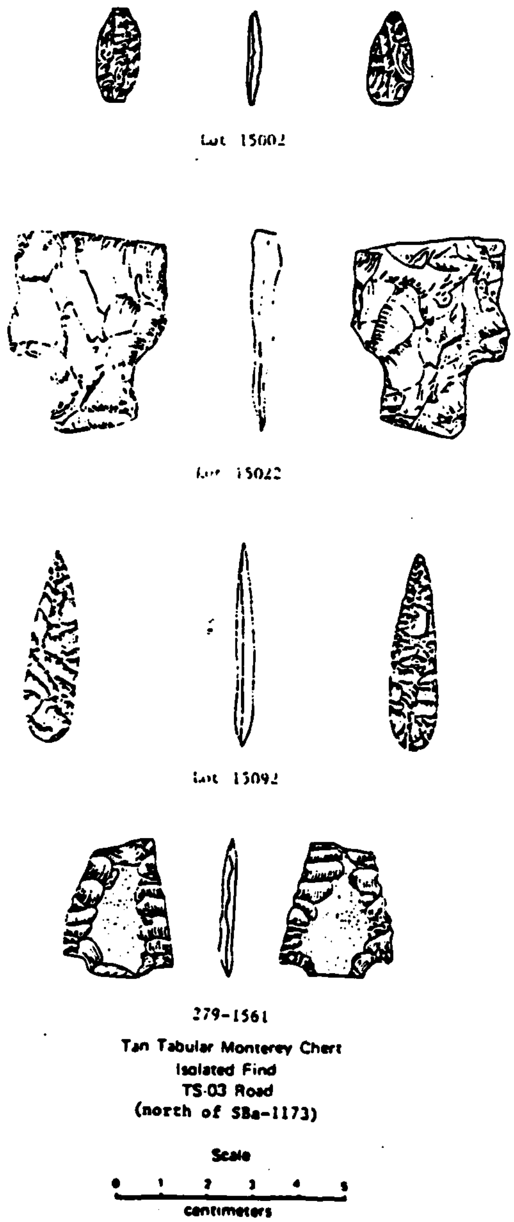

Figure 9-1a. Isolated Projectile Points.

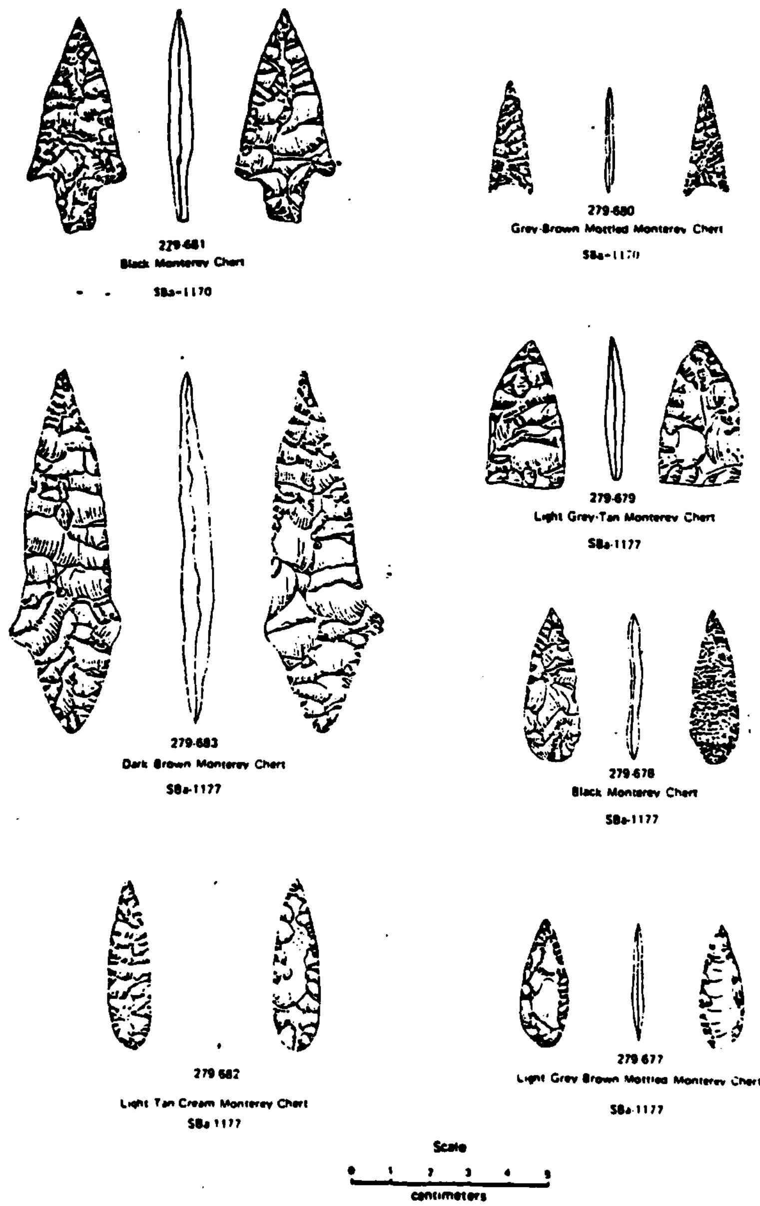

Figure 9-1b. Projectile Points from MAB Sites (Includes SBa-1170 and SBa-1177).

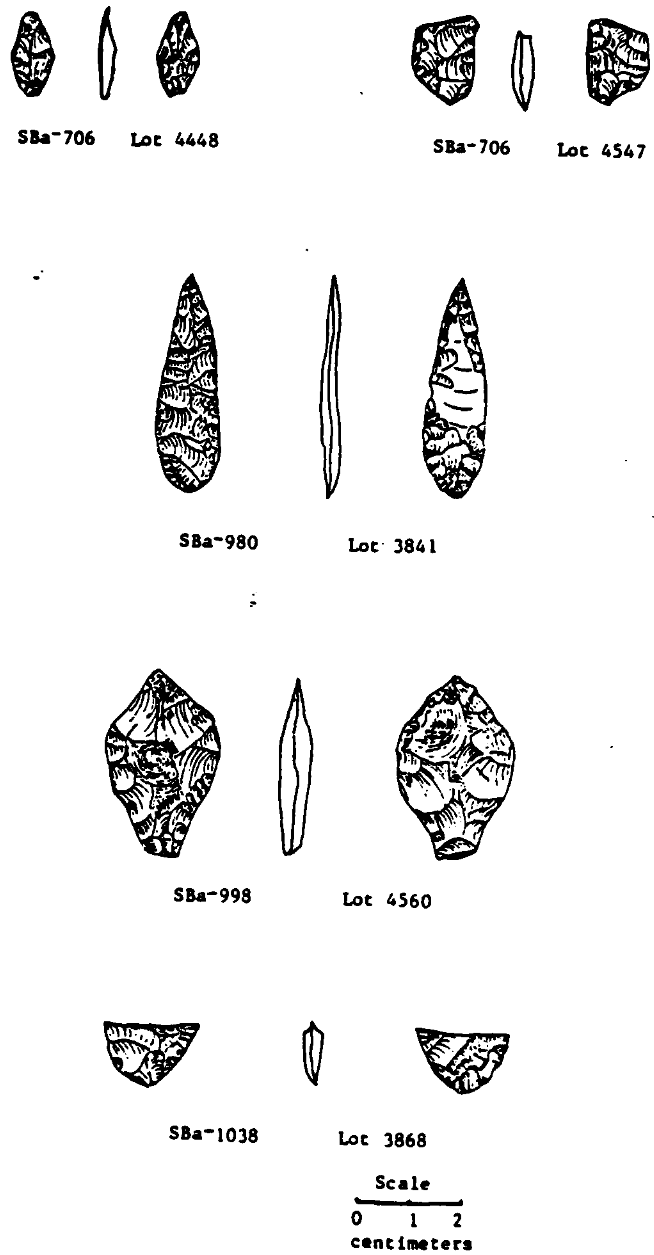

Figure 9-1c. Projectile Points from Fiber Optics/ Communication Line Survey and Testing.

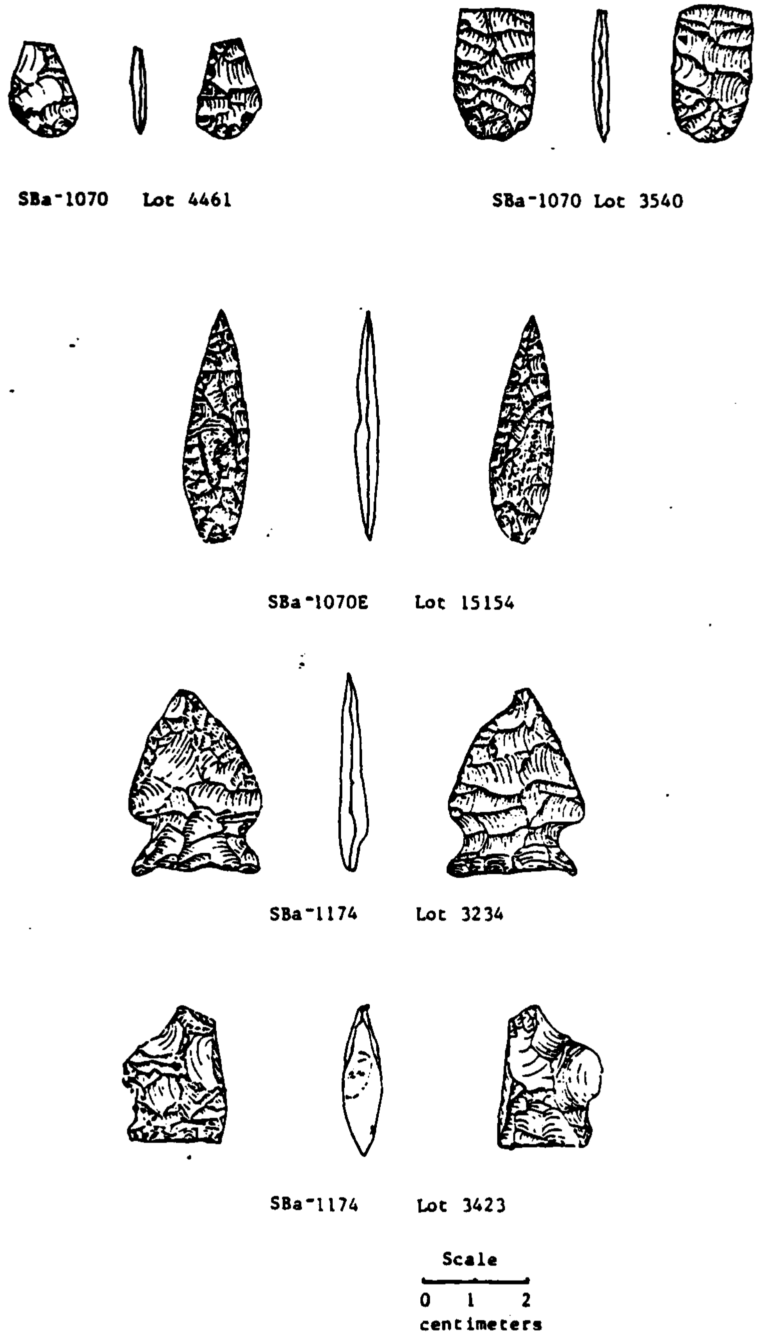

Figure 9-1d. Projectile Points from Fiber Optics/Communication Line Survey and Testing, Stage Storage Facility Monitoring, and 69KV Transmission Line Survey and Testing.

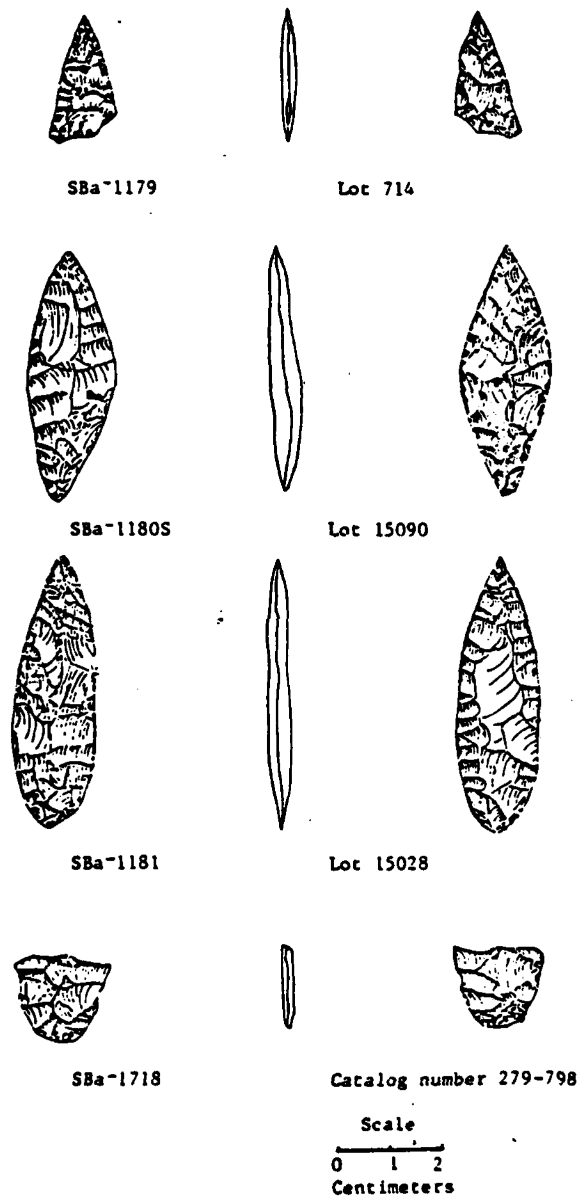

Figure 9-1e. Projectile Points Recovered in the Vicinity of TS-3 Road.

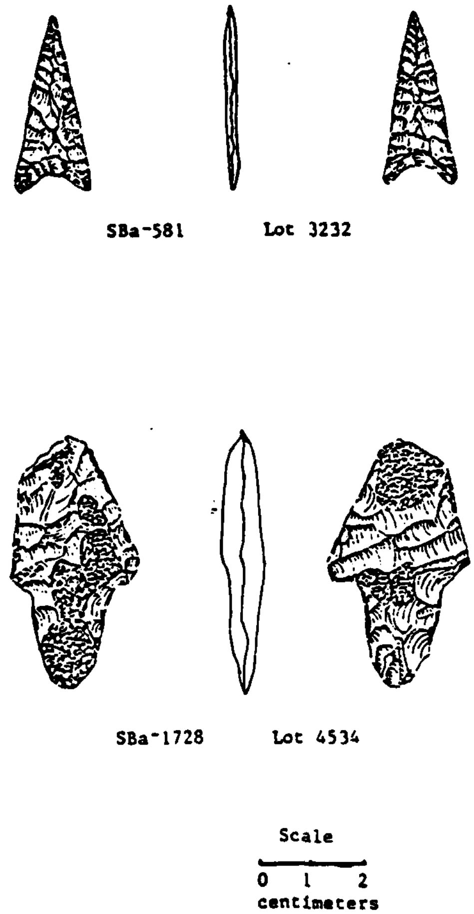

Figure 9-1f. Projectile Points Recovered from SBa-581 and SBa-1728.

the soil by decaying shell; acidity decreases as this process continues. Phosphorus increases as bone decays. Assuming that shell and bone were present in the first place, older sites should have dark soils with high pH (low acidity), and high calcium and phosphorus.

Table 9-10 lists the sites dated by both point typology and soil chemistry, showing the periods indicated by both the points and Rockwell's interpretations of the chemistry. The latter were made taking into consideration the general abundance of lithic and faunal material in each site. Rockwell was able to make a single chronological interpretation of four of the nine sites; there are two possibilities for the other five. The two sources of information do not conflict for three of the four sites with single chemical interpretations. SBa-980 and -1070 contain relatively young point types and SBa-706 is probably protohistoric. All three of these sites contain small leaf-shaped projectile points. SBa-1174, however, contains only early points.

For all of the other five sites, Rockwell offers an option which is consistent with the artifactual evidence. In all cases except SBa-1170, this option implies short occupation, an interpretation which is consistent with the distribution of points discussed above and more detailed analyses discussed in later sections. The contradiction between chemical and artifactual data at SBa-1174 is problematic. The projectile point date for this site is accepted for the present study.

The chemical data on site chronology, then, tend to support the projectile point data. Unfortunately, no single chemistry-based temporal interpretations are available for sites which cannot be dated by projectile points or the radiocarbon method, and there is no way of choosing between the options which are presented. This analysis will therefore be conducted with the sites classified as shown in Table 9-10. Because only three site (SBa-581, SBa-1177, and SBa-1179) are dated to the end of the Late Period by associated projectile points, all recent sites will be lumped together, as will all early sites.

The major problem with this conclusion is in the association between the points and the other artifacts from the various dated sites. The extremely limited and dispersed excavations carried out at most sites precludes the definite demonstration that the collections from each one are in fact the products of a single occupation. The lack of sites with points from more than one period noted above tentatively suggests that occupation over long periods of time were at least rare, but the problem of clear association remains.

This may be particularly true for the sites near San Antonio Creek, which appear to be semi-continuous deposits (R. Brown, personal communication). Reasonably discrete clusters of cultural materials in this region have been designated as distinct sites and are treated separately here. It is clear, though, that the collections are reasonably closely associated with the points. The systematic differences between collections dated to the recent and early periods by their associated projectile points which are discussed in succeeding sections of this report indirectly supports the connection between the points and other artifacts. The condition of the

Table 9-10. Comparison of Dates Based on Projectile Points and Soil Chemistry

Site	Point Type	Chemical Interpretation
SBa-706	recent	Several hundred years old
SBa-980	recent	Young, short occupation
SBa-998	early	Young, or old with a short occupation
SBa-1070	recent	Young, short occupation
SBa-1170	early	Old and leached, or young with a short occupation
SBa-1174	early	Several hundred years old
SBa-1177	recent	Old and leached, or young with a short occupation
SBa-1179	recent	Old and leached, or young with a short occupation
SBa-1718	early	Young, or old with a short occupation

artifacts in the sites also supports the relative ages of the sites containing large and small points. In sites with large points, 42 percent of the artifacts showing edge damage which appears to be from use are too weathered for detailed microscopic examination (see Chapter 6); this is true of only 7 percent of such artifacts in sites with small points, as would be expected if these latter sites are more recent and have thus been exposed to the elements for a shorter time. Lacking better information on site structure, this analysis accepts the projectile point dates, advances interpretations of temporal patterns in the data as hypotheses subject to further test, and notes the possible problem.

Activity Reconstruction

The reconstruction of site activities is the primary goal of this study because it forms the basis for defining 1) what people were doing in the study area, and 2) behaviorally meaningful site types which structure subsequent analysis. A general classification of activities was presented earlier and related to Binford's (1980) site and settlement typology. The study of tool function is clearly critical in inferring specific tasks carried out in a site and placing them within this classification, but additional classes of data are also important; this discussion therefore includes a general analysis of flake distributions and other evidence of tool manufacture and repair. Detailed studies of manufacturing procedures are presented in a later section.

The basis for any study of activities is the functional classification of the tools to be analyzed. Keeley (1930:35-61) and Bamforth (1981) have discussed specific combinations of microwear polishes, edge damage, and striae which indicate specific tool uses. The present discussion will describe only those specific patterns which are prominent in the study collection or are not discussed elsewhere, and will outline the general systematics for assigning tools to the other classes.

Broadly speaking, saws or other cutting tools can be distinguished from scraping tools by the presence of bifacial polish and edge damage with striae parallel or at low angles to the edge; scrapers show mainly unifacial edge damage and polish, with striae generally perpendicular to the edge. The majority of the collection falls into one of these two general classes of tools; other, rarer, classes present include a single drill, a graver, and a ripper. The distinctive traces of these classes are presented by Keeley (1980:35-61).

Specific classes which are important in the study collection include:

- o Skinning tools: These tools show bifacial hide polish and scattered microflaking of various sizes and shapes, with striae at low to moderate angles to the edge. Keeley (1980:55) notes variability in striae angles on tools used in other aspects of butchering where a variety of tool motions are necessary.

- o Butchering tools: Butchering tools have bifacial meat polish and scattered to semi-continuous microflaking of various sizes and shapes, with striae at a wide variety of angles to the edge.

- o Choppers: Keeley (1930:38-40; 4-47) defines choppers by bifacial perpendicular or nearly perpendicular striae and large damage flakes. Choppers in the study collection showed no traces of wood or bone polish; rather, they showed a few abrasion tracks perpendicular to the edge and faint, relatively bright, areas at the edge on both faces. These traces have been replicated experimentally by this author only on tools used to chop through the joints of fairly large animals, such as deer. All choppers in the study collection appear to have been used for this task.

- o Projectile points: Projectile points were initially classified on morphological grounds. However, microscopic examination revealed traces which have never (to this writer's knowledge) been described for any task, and which appear to be the result of use as a projectile, although they have not yet been replicated experimentally. These traces include: 1) striae parallel to the long axis of the artifact, not confined to the edge; 2) faint polish on the distal aspects of flake ridges; and 3) shearing off of high points both near and away from the artifacts' edges. These sheared high points are extremely bright flat points on flake

ridges, which resemble hammerstone smears (see Keeley 1980:28; Plate 8) in appearance but not in size or distribution on the surface. Impact fractures are an additional trace of projectile point use which is fairly well known (see Ahler 1970). One or more of these traces were observed on 21 of the 34 artifacts that would be conventionally classified as projectile points. Artifacts discussed as projectile points in the preceding section include those bearing these traces and morphologically similar artifacts with no other use traces.

The wood working tools include two saws, one scraper, and one graver; the bone working tools include a drill, a saw, and three scrapers; the shell working tools are both scrapers; and the dry hide working tools include a scraper and a ripper. These specific classes are lumped together by worked material in Table 9-11 because there are so few of them.

In addition to these identifiable classes, 32 artifacts which were either retouched or showed edge damage patterns appearing to be from use were too heavily weathered for microscopic examination. It was initially hoped that morphological analysis of functionally interpretable tools would allow the classification of these uninterpretable tools into specific categories, perhaps through discriminant analysis or other multivariate techniques (see Bamforth and Moss, in preparation). However, the large number of functional classes of tools with very small samples in the collection precludes this (a sample of two wood saws, for instance, is insufficient for quantitative comparisons). These functionally uninterpretable artifacts are therefore not included in most of this analysis.

This aspect of the analysis was complicated more than any other by problems of small sample size and possible bias. These problems are discussed specifically as they arise, but they should always be kept in mind. In particular, the samples of only seven dated early sites and nine dated recent sites, not all of which have produced tools, make any conclusions tentative. All interpretations are offered as hypotheses to structure future research.

The analytic methods used here are chosen in response to these problems; the emphasis is on the use of simple, non-parametric statistics. In addition, a flexible approach to significance levels is taken to compensate for small samples, following Cowgill (1977) and Thomas (1976:458-460). Probabilities are presented as exactly as possible, rather than simply noting that they do or do not exceed a given critical value, and are interpreted in light of the sample size.

Two different measures of association are used in the analysis of contingency tables here. For two-by-two tables, Yule's Q was chosen because it is designed for use in tables with unequal marginal totals and is particularly effective in measuring one-way relationships, that is, relationships which involve only one attribute of each of the two variables being studied (Mueller

Table 9-11. Total Used Edges by Site and Specific Use.

Site	Skinning Tools	Butchering Tools	Projectile Tools	Chopping Tools	Hide Scrapers	Plant Knives	Wood Working Tools	Shell Working Tools	Bone Working Tools	Dryhide Working Tools	Unident.	Total
SBa-581			1		1							2
SBa-704	1										2	3
SBa-706	3	4	4	1			3*	2	2		1	19
SBa-980	2	2	1		1				1			7
SBa-998			1	1								2
SBa-1036	4											4
SBa-1038	3*	1*	1				1					4
SBa-1070	1	2*	1								1	4
SBa-1070E		1	1									2
SBa-1155											3	3
SBa-1170			2								2	4
SBa-1173			1								1	2
SBa-1174	1	1	3		2				2	2	5	16
SBa-1176												0
SBa-1177		1	4								1	6
SBa-1179	1	4	1			3	1				1	11
SBa-1180S			1								4	5
SBa-1181			3	1								4
SBa-1718			1									1
SBa-1728			1								2	3
non-site	2	1	6	1	2					1	9	23
TOTAL	18	17	33	4	6	3	5	2	5	3	32	128

*one or more edges represented by resharpening flakes.

and Scheussler 1961:242-252); all of the two-by-two tables in this study have unequal marginals and appear to show relationships of this type. Because of its design, Q attains a value of 1.0 when any one cell in the table is empty.

Q cannot be used for several tables in a later section of this analysis which have more than four cells. The coefficient of contingency (Mueller and Scheussler 1961:262-268) is used for these tables for computational simplicity.

Table 9-12 presents data on each tool examined microscopically, while Table 9-11 shows the number by site of edges used for different tasks. Artifacts showing use for more than one task are recorded once for each task. The totals include both edges from tools sampled from the undifferentiated flakes and those from artifacts examined because of retouch or previous classification as "utilized."

Resharpening flakes, identified by the presence of microwear traces on their platforms, indicate use of four tools in addition to those actually recovered. These are a skinning tool and a butchering knife from SBa-1038, a butchering knife from SBa-1070, and a wood scraper from SBa-706, each represented by a single 1/4-inch flake; they have been added to Table 9-11, where they are noted with an asterisk. These four resharpening flakes out of a total of 172 1/2-inch and 405 1/4-inch flakes whose platforms were microscopically examined indicate that over 99 percent of the unused flakes in the collection were produced in tool manufacture rather than tool modification during use.

This surprisingly low rate of resharpening can be explained by the nature of the activities for which the tools were used. Resharpening is necessary when a tool either breaks or becomes too dull to use. Holding tool material constant, both of these events are most likely to occur while working a material such as wood or bone which is highly destructive of a tool's edge. However, tools used to work those types of materials are rare in the study collection. The tasks which are well represented (skinning and butchering) are those which generally do not result in frequent tool resharpening. Although Frison (1978) notes that bison butchering tools wear out rapidly, with other types of game this is not the case. The most likely animal hunted in the dunes is deer; Patterson (1974; 1976) has butchered an entire deer with a single stone tool on several occasions. The present author's experiments also indicate that processing a deer carcass is not particularly destructive of tool edges. The low number of resharpening flakes identified therefore corresponds with information provided by the recovered tools, which indicates that tasks requiring resharpening were rarely performed.

The tool counts in Table 9-11 are too low to support any complex analysis. To examine the relationship between the various tool types, then, it is possible only to look at their presence or absence in the various sites. Tables 9-13 and 9-14 show the co-occurrences of the various functional tool types for the early and recent sites, derived from the counts in Table 9-11. Entries in these tables are the number of sites in which pairs of tool classes are found together.

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use.

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-581	2852	no	uniface	scraper	fresh hide	complete
	3232	no	concave base point	*	---	complete
SBa-704	15157	no	preform	weathered	weathered	split midsection
	15155	no	large biface	weathered	weathered	complete
	15156	no	large biface	cutting	fresh hide	complete
SBa-706	3446	no	preform	unused	unused	split midsection
	3691	no	preform	unused	unused	split midsection
	3692	no	biface	unused	unused	distal
	3693	yes	flake	cutting	fresh hide	distal
	3707-1	yes	flake	cutting	bone	indeterminate
	3727	no	cobble	chopping	animal joints	complete
	3731	no	preform	unused	unused	midsection
	4205	no	flake	cutting	fresh hide	complete
	4240	no	uniface	unused	unused	split
	4333	yes	flake	cutting	meat (butchering)	midsection
	4440	no	flake	cutting	meat (butchering)	complete
	4445	no	flake	cutting	meat (butchering)	complete
	4445-1	yes	flake	cutting	fresh hide	indeterminate
	4448	no	small leaf-shaped point	*	---	complete
	4462	no	flake	cutting	wood	proximal
	4538a	no	flake	cutting	meat (butchering)	split
	4538b	no	flake	scraping	shell	complete

* morphological "projectile points" showing no evidence of use are listed here as of unknown use.

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-706 (cont.)	4561	no	biface	projectile point	---	distal
	4547	no	small leaf-shaped point	projectile point	---	proximal
	15131	no	biface	unused	unused	broken, fracture type unknown
	15146	no	projectile point	projectile point	---	distal
	15157	no	biface	weathered	weathered	split midsection
SBa-980	3841	no	small leaf-shaped point	projectile point	---	complete
	3842	no	preform	unused	unused	split midsection
	4460	no	uniface	cutting	bone	distal
	4463	no	flake	cutting	meat (butchering)	complete
	4464	no	uniface	scraping	fresh hide	complete
	4464-3	yes	flake	cutting	fresh hide	proximal
	4465-18	no	biface	unused	unused	midsection
	4465-45	yes	flake	cutting	meat (butchering)	midsection
	4465-46	yes	flake	cutting	meat (butchering)	complete
	4472	no	preform	unused	unused	proximal
SBa-998	4488	no	cobble	chopping	animal joints	complete
	4559	no	biface	unused	unused	midsection
	4560	no	stemmed point	projectile point	---	complete

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-1036	267-22	yes	flake	cutting	fresh hide	complete
	267-73	yes	flake	cutting	meat (butchering)	proximal
	267-116	no	biface	cutting	fresh hide	split midsection
	267-354	yes	flake	cutting	fresh hide	complete
	267-564	no	uniface	scraping	fresh hide	complete
SBa-1038	3868	no	small leaf-shaped point	*	---	proximal
	4503	yes	flake	cutting	fresh hide	split distal
	4506-1	yes	flake	cutting	fresh hide	proximal
	267-764-1	yes	flake	cutting	plants	distal
	267-803	no	preform	unused	unused	split
	267-959	no	preform	unused	unused	split midsection
SBa-1066	2374	no	preform	unused	unused	split
SBa-1070	3540	no	small leaf-shaped point	projectile point	---	proximal
	3541	no	leaf-shaped biface	projectile point?	---	proximal
	3542	no	biface	cutting	meat	proximal
	4461	no	small leaf-shaped point	unused	unused	proximal
	4461-16	no	uniface	cutting	fresh hide	complete

* morphological "projectile points" showing no evidence of use are listed here as of unknown use.

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-1070E	3238	no	biface	cutting	meat	proximal
	15145	no	small leaf-shaped point	weathered	weathered	complete
SBa-1155	2094	no	preform	weathered	weathered	broken, fracture type uncertain
	3201	no	core?	weathered	weathered	complete
	3203	no	flake	weathered	weathered	complete
SBa-1170	267-187	no	biface	weathered	weathered	distal
	279-681	no	stemmed point	projectile point	---	complete
SBa-1173	15024	no	dart point	weathered	weathered	distal
	279-1561	no	stemmed point	weathered	weathered	midstection
SBa-1174	2321	no	drill	drill	bone?	distal
	3234	no	corner-notched point	weathered	weathered	complete
	3295a	no	biface	scraping	unknown	split midsection
	3298b	no	uniface	cutting	fresh hide	complete
	3298c	no	biface	weathered	weathered	midsection
	3295d	no	uniface	scraping	fresh hide	complete
	3298e	no	uniface	unused	unused	distal
	3298f	no	uniface	scraping	fresh hide	split distal
	3298g	no	possible bladelet core	weathered	weathered	complete

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-1174 (cont.)	3298h	no	biface	weathered	weathered	split midsection
	3298-2	yes	flake	scraping	bone/antler	proximal
	3298-8	yes	flake	cutting	fresh hide	distal
	3298-11	yes	flake	ripping	dry hide	split distal
	3298-15	yes	flake	scraping	dry hide	complete
	3405	no	uniface	weathered	weathered	complete
	3423	no	stemmed point	projectile point	---	midsection
SBa-1176	4439	no	biface	unused	unused	midsection
SBa-1177	279-677	no	small leaf-shaped point	projectile point	---	complete
	279-678	no	small leaf-shaped point	projectile point	---	complete
	267-680	no	concave-based point	*	---	complete
	279-682	no	small leaf-shaped point	projectile point	---	complete
	279-683	no	biface	cutting	meat	complete
	279-691	no	uniface	unused	unused	proximal
	279-707	no	flake	weathered	weathered	midsection
SBa-1179	431	no	preform	unused	unused	distal
	636a	no	flake	cutting	meat (butchering)	complete
	636b	no	flake	cutting	wood	complete

* morphological "projectile points" showing no evidence of use are listed here as of unknown use.

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-1179 (cont.)	691	no	flake	1) cutting 2) cutting	plants meat (butchering)	complete
	692	no	flake	1) cutting 2) cutting	plants meat (butchering)	complete
	714	no	concave-base point	projectile point	---	complete
	717	no	preform	unused	unused	midsection
	731	no	flake	cutting	fresh hide	complete
	733a	no	flake	weathered	weathered	complete
	733b	no	flake	weathered	weathered	complete
	15144a	no	preform	unused	unused	complete
	15144b	no	flake	cutting	meat (butchering)	complete
SBa-1180S	15041	no	flake	weathered	weathered	complete
	15053	no	flake	weathered	weathered	complete
	15055	no	biface	weathered	weathered	midsection
	15090	no	stemmed point	projectile point	---	complete
	279-483	no	flake	weathered	weathered	distal
SBa-1181	150011	no	leaf-shaped biface	projectile point	---	complete
	15003	no	point	projectile point	---	midsection
	15028	no	small leaf-shaped point	projectile point	---	complete
	15062	no	cobble	chopper	animal joints	complete

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
SBa-1718	279-798	no	stemmed point	*	---	proximal
SBa-1725	4533	no	biface	weathered	weathered	midsection
	4534	no	stemmed point	weathered	weathered	proximal
SBa-1730	3641	no	flake	cutting	meat (butchering)	complete
	15019	no	uniface	weathered	weathered	proximal
Non-Site	733a	no	flake	weathered	weathered	complete
	733b	no	flake	weathered	weathered	complete
	2658	no	flake	cutting	*meat* (butchering)	complete
	3226	no	leaf-shaped biface	projectile point	---	complete
	3227	no	uniface	weathered	weathered	complete
	15000	no	preform	unused	unused	proximal
	15002	no	small leaf-shaped point	projectile point	---	proximal
	15022	no	stemmed point	weathered	weathered	proximal
	15039	no	flake	cutting	fresh hide	split
	15047	no	flake	cutting	wood	split
	15092	no	small leaf-shaped point	projectile point	---	complete
	15093	no	flake	cutting	fresh hide	complete
	15095	no	flake	weathered	weathered	complete

* morphological "projectile points" showing no evidence of use are listed here as of unknown use.

Table 9-12. Data from Detailed Microscopic Examination of Artifacts from Intensive Sample with Use Traces, All Retouched Artifacts, and all Unretouched Artifacts Designated "Tools" by CCP and Whose Edges Show Traces of Use (Continued).

Site #	Artifact	Intensive Sample?	Type	Mode of Use	Worked Material	Fragment
Non-Site (cont.)	15122	no	flake	1) cutting 2) cutting	fresh hide fresh hide	complete
	15126	no	projectile point	*	---	distal
	279-679	no	triangular biface	projectile point	---	complete
	279-719a	no	flake	cutting	fresh hide	split
	279-719b	no	flake	chopping	animal joints	complete
	279-770	no	uniface	scraping	fresh hide	complete
	T-063	no	flake	weathered	weathered	complete

* morphological "projectile points" showing no evidence of use are listed here as of unknown use.

These tables both show that the classes represented cannot be broken down into "toolkits" off the sort made famous by the Binfords (Binford and Binford 1966). There are no groups of tools which tend to occur together and which also tend not to be found with some other groups of tools. Rather, all functional types seem to occur together, with the number of co-occurrences of any pair of classes depending mainly on the frequency of those classes in the collection. There appears to be only one "toolkit" (in a general sense) present during the two periods, with some kinds of tools more frequently represented than others.

The most closely interrelated tool types (skinning and butchering knives, projectile points, and choppers) together form a kit which is obviously related to the hunting and processing of large game; choppers, in particular, are necessary in processing small game such as rabbits or birds. Fresh hide scrapers can be added to this kit for processing skins. The dominance of this kit in both periods and the undated sites (they comprise 80 percent of the tools of known function) indicates that hunting was the major activity carried out on the terrace. Plant knives also indicate resource collection, possibly for food (although most food plants can be harvested without stone tools) and possibly for other uses such as basket manufacture.

The general types of tools present and the distribution of projectile points and point fragments support the notion that game processing took place in the sites themselves. Keeley (1982) outlines the different spatial distributions which we can expect to see for hafted and unhafted tools. Briefly, he discusses evidence showing that hand-held, unhafted tools are likely to be discarded at or near the location of a task when that task is completed, while hafted tools are likely to be abandoned where they are replaced in the hafts. This is because the time and energy required to make a haft vastly outweighs that required to make a stone tool.

The tools in the study collection, other than projectile points, can be divided broadly into unmodified flake tools and unifaces, none of which show any morphological or microscopic evidence of hafting, and bifaces, which were

Table 9-13. Co-Occurrence Matrix of Functional Tool Types, Early Sites.

	s	b	pt	hs	bo	dh	ch
skinning tool (s)	1	1	1	1	1	1	0
butchering tool (b)		1	1	1	1	1	0
projectile point (pt)			5	1	1	1	1
hide scraper (hs)				1	1	1	0
bone working tool (bo)					1	1	0
dry hide working tool (dh)						1	0
chopper (ch)							1
Total Number of Tools	(1)	(1)	(8)	(2)	(2)	(2)	(1)

Table 9-14. Co-Occurrence Matrix of Functional Tool Types, Recent Sites.

	pt	b	s	ch	bo	w	pl	sh	hs
projectile point (pt)	9	6	5	3	2	2	2	1	2
butchering tool (b)		6	4	2	2	2	1	1	1
skinning tool (s)			5	2	2	2	2	1	1
chopper (ch)				3	2	1	0	1	1
bone working tool (bo)					2	1	0	1	1
wood working tool (w)						2	1	1	0
plant knife (pl)							2	0	0
shell working tool (sh)								1	0
hide scraper (hs)									2
Total Number of Tools	(17)	(13)	(9)	(3)	(3)	(3)	(4)	(2)	(2)

apparently hafted (some, in fact, retain asphaltum at one end). Of the 44 tools used for some aspect of carcass processing, 39 are unr odified flakes or unifacially retouched. Of the seven unifaces, five are hide scrapers, a task which generally requires a relatively steep, regular edge which can frequently be obtained only by retouch (see Bamforth 1981). Only two of the bifaces are complete. Under Keeley's hypothesis, these patterns clearly imply on site use.

The projectile points and point fragments can be considered from a similar perspective. Broken used projectile points that are recovered in sites were probably damaged in use: the base would be removed with the arrow or dart shaft, while the tip would remain imbedded in the animal. This tip would then be recovered when the animal was butchered. The base could be discarded at a retooling area, or possibly with the broken shaft if it snapped off inside the animal and would not be salvaged. Complete, used but still useable points would be discarded under circumstances similar to tips--if the shaft is broken, it is more trouble to extract the point than to make a new one. The presence of complete points and tips in these sites suggests that they were the scene of fairly complete butchering.

A basic distinction can be made between tools used directly for resource procurement and processing--the apparent reason for occupying the sites in the study area--and tools used to maintain people and equipment. In the collection considered here, the former include those used for hunting, butchering, and plant collecting. The latter include those used for all other activities (i.e., for wood, shell, bone, and dry hide working).

The tools used for activities other than hunting, butchering and plant collecting indicate group maintenance and tool repair and manufacture. The two periods differ somewhat in the variety of these activities represented. However, the small numbers of artifacts involved and the large proportion of heavily weathered and therefore functionally uninterpretable early artifacts (42 percent, compared to 7 percent in the recent sites) suggest that these differences are not meaningful. The proportion of projectile points in assemblages from both periods is also virtually identical (26 percent in the early sites and 29 percent in the recent sites), further supporting the basic similarity of these two parts of the collection.

The undated sites and isolated artifacts from the study area conform to this general pattern as well. The isolates may indicate that similar sets of activities were carried out on and off sites. However, the constant dune movement may have simply obscured the sites with which the isolates were actually associated.

The location of tool manufacture is indicated by flake frequencies. The data from the study collection show a clear pattern of decreasing density of flakes per cubic meter of excavation as distance from the edge of the terrace increases (Table 9-15): distances were measured from the center of each site to the nearest edge of the terrace, with "edge" defined by the drainages on the north, south, and east boundaries. Distances for sites outside of these limits were taken as zero. For most sites, the closest edge was to the south.

Table 9-15. Density of Flakes and Distance into Terrace by Site.

Site	Period	Flakes/M^3	Distance to Terrace Edge
SBa-581	recent	2.2	2900 m
SBa-704			0 m
SBa-706	recent	50.6	1000 m
SBa-980	recent	201.0	400 m
SBa-998	early	2.9	1400 m
SBa-1036		7.9	300 m
SBa-1037		200.0	200 m
SBa-1038	recent	34.8	200 m
SBa-1052		2.6	0 m
SBa-1070	recent	165.4	900 m
SBa-1070E	recent	1.0	1150 m
SBa-1155		1.4	2200 m
SBa-1170	early	73.7	2100 m
SBa-1174	early	15.2	0 m
SBa-1179	recent	.9	2900 m
SBa-1180S	early	9.8	3250 m
SBa-1181	recent	16.7	2400 m
SBa-1718	early	13.5	2800 m

However, studying flake densities is complicated by sampling problems in addition to small numbers of artifacts which result from the kinds of excavations carried out at most of the sites in the sample. First, without systematic testing to define fully the limits of the sites, we cannot be sure of the sampling fractions taken. Second, a substantial proportion of the excavation at all sites took the form of small, dispersed shovel test pits rather than fewer but larger blocks. Third, virtually all excavation of all kinds was done in direct impact areas regardless of the surface indications of the internal structure of the site. The result of these problems is that it is impossible to know how representative the excavated samples are of the sites from which they were taken. These considerations put definite limits on the analytic methods which can be used here.

Figure 9-2 plots flake density against distance to the terrace edge for all recent sites. Ignoring the data from SBa-1038, where excavation in the impact area is known to have missed concentrations of artifacts outside it, there appears to be a sudden drop in flake density at roughly 1,000 m. Pearson's r computed on the raw flake frequencies and distances (including SBa-1038) suggests that this relationship is fairly strong ($r=-.61$, $df=7$, $.05$ greater than p greater than $.025$ for a one-tailed test). Although the relationship intuitively appears to be markedly non-linear (the line in Figure 9-2 indicates roughly a possible curve), Pearson's r computed between the common logarithm of flake densities and the raw distances does not substantially change the value of r ($r=-.65$, $df=7$, $.05$ greater than p greater than $.025$).

The failure of this transform to substantially increase the correlation suggests that the relationship between flake density and distance from the terrace edge is not one of continuously decreasing densities as one goes farther and farther into the dunes, but rather a dichotomous one with a distance of 1,000 m marking a region close to the edge with many flakes ($\bar{x}=112.91$, $SD=82.7$, $n=4$) and a region far from the edge with few flakes ($\bar{x}=4.8$, $SD=8.0$, $n=4$). A more flexible non-parametric statistic, the runs test (Thomas 1976:337-339), supports this pattern. Dividing the sites into those 1,000 m or closer to the terrace edge and those farther away and plotting the two groups against flake density produces two runs, with all of the closer sites having higher densities than any of the others. This is exactly what the hypothesis predicts; two runs with two groups of four observations each is significant at the .025 level with direction of the relationship specified.

The early sample of sites ($n=5$) is too small for virtually any quantitative analysis. The limited data which are available, however, suggests a contrast with the recent pattern of flake distribution. All early sites have flake densities which fall between the extremes for recent sites. Although the presence of only one early terrace edge site make quantitative comparisons of sites in that area impossible, the data on early and recent intermediate dune sites can be studied. The mean density of flakes in early intermediate dune sites is substantially higher ($x=25.0$, $SD=32.8$, $n=4$) than in similarly located recent sites ($x=4.8$, $SD=8.0$, $n=4$). This difference is significant past the .02

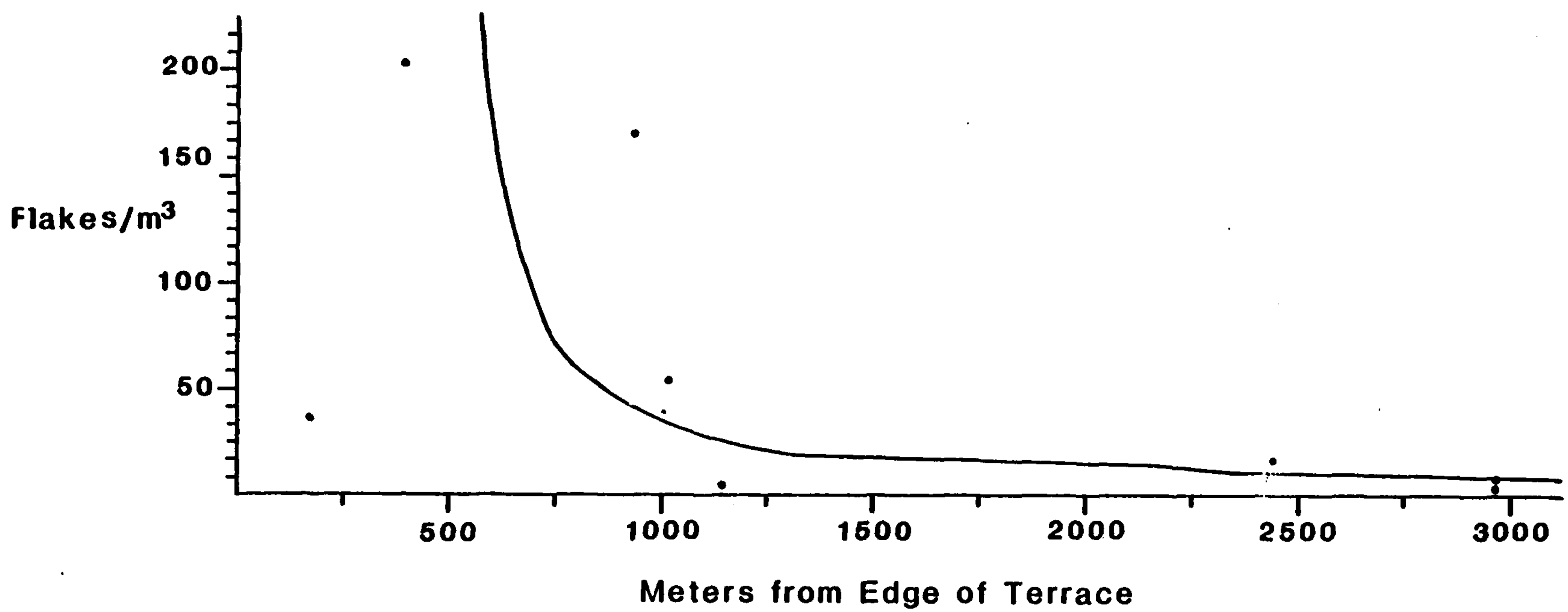

Figure 9-2. Density of Flakes per Cubic Meter Plotted Against Distance to Terrance Edge for Recent Sites.

level (t=5.2, df=5), and probably implies less segregation of activities within the terrace during the earlier period than seems to have existed during the recent period.

This difference is flake concentrations between the periods suggests that two additional sites, SBa-704 and SBa-1037, may date to recent times. Both of these sites have flake densities which fall into the range for recent sites near the edge of the terrace, where they are both located. When these two sites are included with the dated recent sites in computing the correlation between the log of flake densities and raw distances, the correlation is strengthened substantially (r=-.74, df=9, .005 greater than p greater than .0005) as is the correlation using raw flake densities (4=-.71, df=9, .01 greater than p greater than .005). The flake densities in the other undated sites are also compatible with these overall patterns, although they are not indicative of a specific period of occupation.

The pattern of flake densities in recent sites suggests that dividing the terrace into a section close to its edge and a section in the central portion of the intermediate dunes may provide important insights into prehistoric activities carried out at there, at least for the recent period. Several other analyses in this section will search for additional evidence for the importance of this division.

The distribution of preforms in the terrace shows a similar pattern to that of the flake densities. Preforms are defined here as relatively large, generally incomplete, bifaces with large, fairly deep flake scars and sinuous edges (see Arnold 1981; Spanne 1975b). None of the artifacts of this type in the collection shown any microscopic evidence of use, although as Spanne (1975b:50-51) notes, edge damage is common on them. This lack of use and the common close association of these artifacts with large chert outcrops (Spanne 1975b) indicates that they represent an intermediate stage in biface manufacture.

Table 9-16 presents the frequencies by site of preforms and the large bifaces which were presumably manufactured from them. Table 9-17 shows the frequencies of these two classes of artifacts by period. These frequencies show a clear contrast between the two periods in the frequencies preforms present (chi-square=7.19, df=1, .01 greater than p greater than .005, Yules Q=1.0): early sites typically contain somewhat more frequent bifaces but no preforms, while recent sites contain both. Spanne (1975b) states that preforms are common throughout the prehistoric sequence in the Vandenberg region; their scarcity in early sites on the San Antonio Terrace therefore probably does not simply reflect their regional scarcity.

The distributions of maintenance and other activities, as indicated by the locations of the tools recovered, parallel the distribution of flakes, particularly in recent sites. Tables 9-18a and 9-18b show the frequencies of maintenance and processing tools (as defined earlier) for the central portion of the intermediate dunes (more than 1,000 m from the terrace edge) and other sites for the early and recent periods. Both tables show a similar absence of maintenance tools in the intermediate dunes (early: chi-square=2.8,

Table 9-16. Frequencies of Preforms and Large Finished Bifaces by Site.

Site	Preforms	Large Bifaces	Total
SBa-581			0
SBa-704	1		1
SBa-706	4	3	7
SBa-980	2		2
SBa-998		1	1
SBa-1036			0
SBa-1038	2		2
SBa-1070		2	2
SBa-1070E		1	1
SBa-1155	1		1
SBa-1170		1	1
SBa-1173			0
SBa-1174		3	3
SBa-1176	1		1
SBa-1177		1	1
SBa-1179	3		3
SBa-1180S		1	1
SBa-1181		1	1
SBa-1718		0	0
SBa-1728		1	1
non-site	2	5	7
TOTALS	16	20	36

Table 9-17. Frequency of Preforms and Large Finished Bifaces by Period.

	Early	Recent	Totals
preforms	0	11	11
finished bifaces	7	8	15
	7	19	26

Table 9-18. Maintenance and Processing Tools by Site Location.

Table 9-18a. Recent.

	Maintenance Tools	Processing Tools	Totals
terrace edge	7	25	32
central dunes	1	23	24
	8	48	56

Table 9-18b. Early.

	Maintenance Tools	Processing Tools	Totals
terrace edge	4	7	11
central dunes	0	8	8
	4	15	19

Table 9-18c. Overall.

	Maintenance Tools	Processing Tools	Totals
terrace edge	11	32	43
central dunes	1	31	32
	12	63	75

df=1, .1 greater than p greater than .05, Yules Q=1.0; recent: chi-square=5.7, df=1, .025 greater than p greater than .01, Yules Q=.64). Lumping the two periods together (Table 9-18c) produces stronger patterning (chi-square=7.68, df=1, .01 greater than p greater than .005, Yules Q=.84). The data suggest, then, that although resource procurement and processing was carried out in all parts of the terrace, group maintenance and tool manufacture and repair activities tended to be carried out outside of the central portion of the intermediate dunes.

The dichotomy this implies between terrace edge and central dune sites seems especially clear for the recent data when flake frequencies are also considered, but the early pattern is problematic. This is because all of the early maintenance tools come from a single site, SBa-1174, which is located on the northeast edge of the study area (Table 9-11). This site is not strictly on the San Antonio Terrace; it is in the adjacent foothills, and therefore may not be directly comparable to the other sites. The absence of maintenance tools in early sites which are actually on the terrace may simply reflect the small sample available.

Table 9-19 shows the frequency of projectile points and point fragments divided between central dune and other sites by period. Fragment type is dichotomized as proximal, which would be discarded while retooling if the haft unusable fragments tend to be discarded in both central dune and terrace edge sites, which proximal fragments tend to be found in terrace edge sites (chi-square=5.9, df=1, .025 greater than p greater than .01, Yules Q=.88). This evidence indicates that retooling of projectiles tended to take place near the terrace edge, paralleling the other evidence for a concentration of maintenance activities there. The data for the early sites are random (p=.42 by Fisher's exact test), suggesting that this activity was carried out in all parts of the study area.

Table 9-19. Frequencies of Projectile Point Fragments By Period and Site Location

	Terrace Edge	Central Dunes	Total
Recent			
proximal fragment	5	1	6
other	4	12	16
	9	13	22
Early			
proximal fragment	0	2	2
other	3	4	7
	3	6	9

In summary, both early and recent sites show similar sets of activities dominated by a tool kit used to kill and process large animals: all sites on the terrace appear to be hunting camps. Early sites, however, contain larger numbers of finished bifaces, relatively higher flake densities in the central portion of the intermediate dunes, and no preforms. But no early sites contain flake densities comparable to those in recent sites such as SBa-980 or SBa-1070.

Recent sites appear to be divisible into those within 1,000 m of the edge of the terrace where the bulk of tool manufacture and repair took place and those in the central portion of the intermediate dunes which were used almost exclusively for processing freshly killed carcasses. Early sites may show a similar concentration of non-processing tools outside the central dunes, but do not show any perceptible variation in stone tool manufacture or projectile point repair in different areas. The lack of debitage in early sites is paralleled by an absence of preforms and a relative abundance of finished bifaces, indicating that most biface manufacture occurred outside the study area. This topic is explored in more detail in a later section.

The temporary nature of recent occupation in the central dunes is shown most clearly at SBa-1179, where large-scale block excavations have apparently exposed most of the site (Figure 9-3). Nowhere within the excavations is it possible to define a clear activity area on the basis of chipped stone artifacts; similarly, there is no central dumping area. Manufacturing debris (unused flakes and broken or discarded preforms) is sparsely scattered through most of the exposed area. A rejected preform was recovered from the north edge of the site in association with three flakes which can be refitted to it, suggesting that the dispersion of artifacts is not due to post-depositional factors.

Functional classes of tools show an equally unpatterned distribution. Butchering and skinning tools are found at both the north and south ends of the excavation, two near the preform just mentioned and one associated with a wood saw. Abalone tool fragments, a few flakes, and a projectile point occur together in the northern excavation block. Schiffer (1972) points out that a lack of segregation of activities is typical of temporary habitation sites, an inference supported here by the low density of artifacts present.

The recent sites then fall into two groups: SBa-706, -980, -1038, and -1070, within 1,000 m of the terrace edge and with relatively frequent non-processing tools, evidence for projectile retooling and high flake densities; and SBa-581, -1070E, -1177, -1179, and -1181, all more than 1,000 m from the terrace edge and with few non-processing tools and low flake densities. The division of early sites into these two groups is less clear--there is no evidence for spatial segregation of tool manufacture or projectile repair, and the distribution of maintenance tools is problematic. SBa-1174 may correspond to the first group of sites and SBa-998, -1170, -1173, -1180S, -1718, and -1728 to the second.

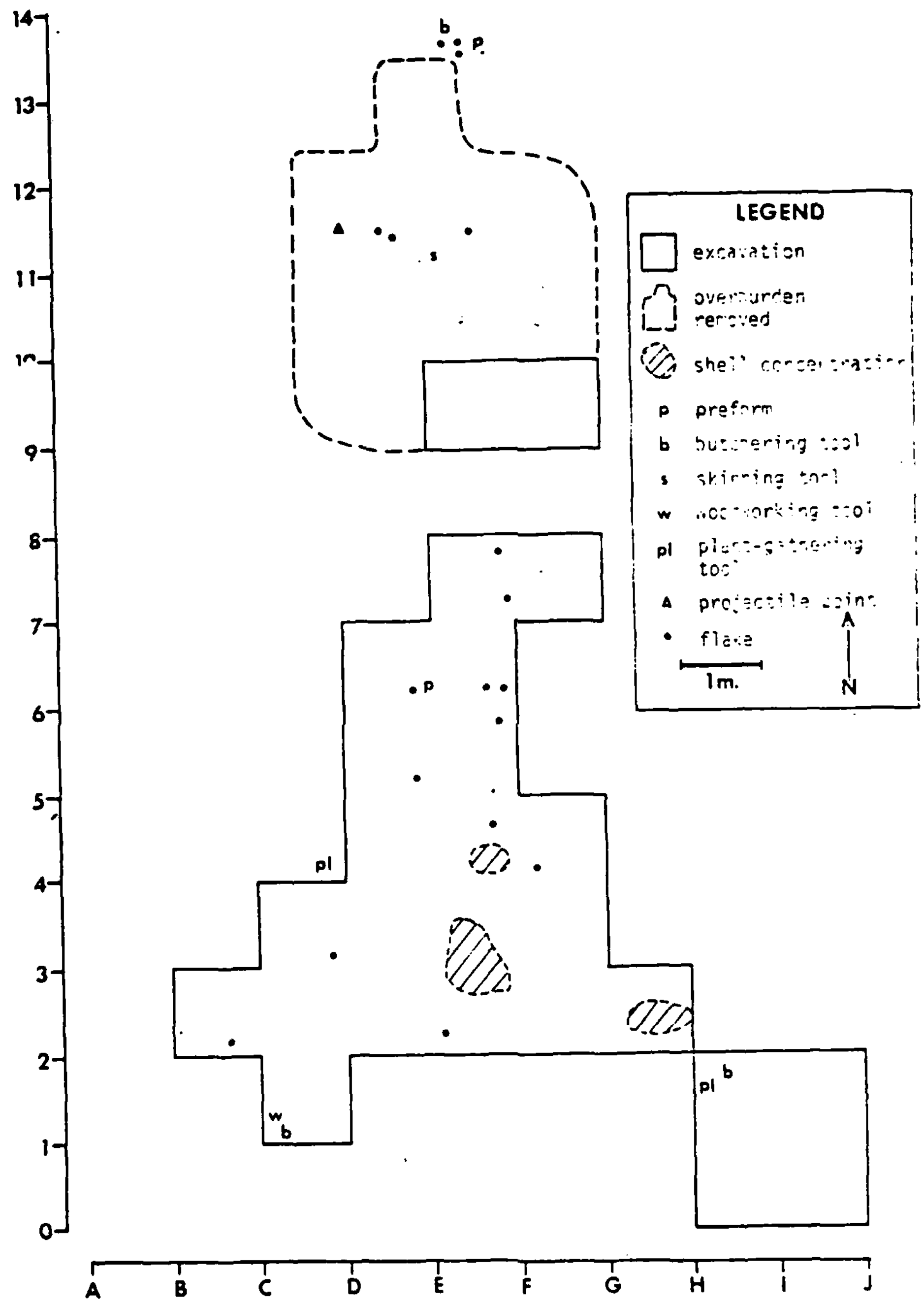

Figure 9-3. Plan of Excavations and Distribution of Recovered Materal at SBa-1179.

All of these sites seem to fall into Binford's (1980) field camp category: the diversity of tools and presence of waste flakes indicate all categories of activity except extraction, suggesting some type of habitation, but the assemblages are uniformly dominated by tools used to acquire and process a single resource. The systematic variability in the recent sites within this single class of sites indicates a somewhat more complicated pattern than Binford describes, adapted to the specific conditions of the study area. The dunes closer to the edge of the terrace tend to be better stabilized by vegetation than those farther away, reducing the amount of sand which can be whipped up by the high winds which are typical of the area. Travel in the loose sand of the central portion of the intermediate dunes is difficult, and blowing sand can make even sitting still uncomfortable. Minimizing occupation in this environment makes considerable sense.

Quarry Use

In Chapter 8, Grivetti discusses variability in the nature and occurrence of chert in the area around the San Antonio Terrace, and concludes that material color and cortex appearance are the only variables which allow an artifact to be traced back to its source. He distinguishes five color categories: "very black," indicating coastal bedrock and cobble outcrops of the Middle Monterey Formation near Purisima Point, Lions Head, and Mussel Rock; "yellow-red laminated," indicating terrace cobble exposures on the south edge of Burton Mesa; "gray-blue-brown," indicating inland occurrences of the Middle Monterey Formation, with bedrock exposures found in the Casmalia Hills north of the study area and cobbles in adjacent terrace exposures; "Franciscan" color, generally opaque, non-laminated browns and greeenish blues, which is found only in very granular form in the region near the study area; and "other," which occurs throughout all members of the Monterey Formation, and is not diagnostic of a particular location.

Grivetti's analysis allowed him to rank potential source areas according to their Exploitation Potential (EP), a measure combining assessments of the size of the raw pieces that are available, the degree of fracturing in the pieces, the amount of material available at the source, and the difficulty of extracting the material. The EP then allows a ranking of potential sources which predicts their volume of prehistoric use on the basis of knapping qualities and difficulty of procurement. This ranking is shown in Table 9-20. The characteristics of the various source areas which result in this ranking are as follows. Of the bedrock outcrops, inland Middle Monterey outcrops are more fractured and harder to quarry than coastal outcrops; the coastal outcrops at Lions Head produce small, fractured pieces which are difficult to extract, and the single Franciscan outcrop known at Point Sal produces small amounts of granular chert in small, fractured pieces that are difficult to extract. Chert clasts in terrace exposures tend to be small, somewhat fractured, and difficult to find.

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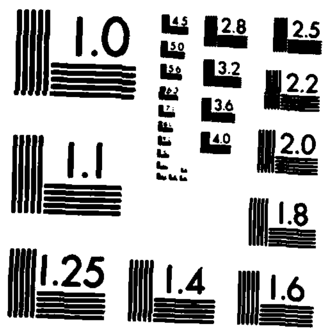

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Table 9-20. Ranking of Potential Chert Source by Exploitation Potential (EP).

EP	Source
11	Coastal outcrops at Purisima Point and Mussel Rock containing abundant beach clast and thick, unfractured bedrock outcrops
9 to 10	Inland bedrock outcrops of the Middle Monterey Formation
6 to 7	Terrace exposures; coastal outcrop of Middle Monterey Formation at Lion's Head.
4 to 5	Other Monterey Formation bedrock outcrops; local Franciscan outcrops.

The regional organization of chert procurement obviously cannot be completely explicated on the basis of the data from the San Antonio Terrace. However, comparison of the rank order predicted by the EP and the actual debitage frequencies can provide important insights. If the EP correctly predicts the rates of chert usage in the study area, it is likely that there was either some means of distributing preferred raw material throughout the region or that the hunters on the terrace came primarily from nearby coastal villages near the preferred sources. Major villages on the Vandenberg coast are frequently associated with important chert outcrops (Arnold 1980; Spanne 1975b) and such villages are known at the coastal Middle Monterey outcrops just south of the study area at Purisima Point. Alternatively, the outcrops might be exploited on an encounter basis. If this is the case, the sources might be exploited according to their distance from the sites.

There are several problems in testing these hypotheses. The first is distribution within the study area of sites from which collections are available. No collections are included from the north edge of the terrace, closest to the inland Middle Monterey bedrock outcrops in the Casmalia Hills. If the second hypothesis is correct, these sites should contain the highest proportions of gray-blue-brown chert. This biases the data towards the first hypothesis. The small size of the collections from many sites also increases the possibility of errors in interpretation.

It is also difficult to classify accurately flakes and other artifacts into all of the classes that are needed to test directly these two hypotheses. The distinction between color categories is generally relatively straightforward, but both of the major bedrock sources also occur as cobbles in either beach or terrace deposits. Problems with this classification arise because the beach cobbles are derived from the coastal bedrock outcrops and frequently can be collected before they are transported very far, and thus, before their exterior has been very weathered; many cobbles on the beach have a fairly

fresh shale cortex on them. Beach deposits are directly associated with coastal bedrock outcrops so that this distinction is not critical in inferring this general source area, but this is not true of inland terrace and bedrock exposures. It is possible to distinguish inland bedrock from terrace sources when cortex is present on the object being examined, but for flakes removed after the cortex is gone or for completely retouched pieces these two types of stone are indistinguishable.

This analysis will then first examine use of general source areas as inferred from color categories. We can broadly distinguish between coastal Monterey chert (very black), inland Monterey chert (gray-blue-brown), Franciscan chert, and chert from the south edge of Burton Mesa (yellow-red laminated). Within these categories, it is then possible to examine the relative frequencies of flakes with bedrock and cobble cortex (except, of course, for the material from the south edge of Burton Mesa, all of which comes from terrace exposures).

In addition to these chert varieties, the analysis includes an "other" category, comprised of two pieces of fused shale and 12 pieces of shale, quartzite, and unidentified stone. This analysis includes all flakes larger than 1/4 inch from all dated sites and undated sites which were sampled for intensive analysis.

Table 9-21 shows the frequencies by site of the material types defined above. The most obvious pattern in these data is the overwhelming dominance of coastal Monterey chert in all sites with samples large than ten flakes. This pattern is present in early and recent sites, and in intermediate dune and other sites. There is no relationship between the percent of very black chert and distance to the closest outcrop over all of the sites examined (r=-.15, df=6) or by period (early: r=.14, df=3; recent: r-.11, df=6). The frequencies of the other color categories vary somewhat but specific categories show no strong pattern. Only from SBa-1174 is there a collection of more than 10 flakes with a fairly substantial proportion of other than very black chert--in this case, gray-blue-brown. SBa-1174 is the closest site to the Casmalia Hills where bedrock occurrences of this material are found. While this might suggest a tendency for earlier sites to deviate from the EP predictions, over two-thirds of this collection is very black and the collections from other early sites do not differ from those from later sites. The relative proximity of SBa-1174 to the inland chert outcrops, though, suggests that this difference may indicate locally more intense use of lower quality resources. Additional evidence for this is discussed in the following section.

Despite this lack of change in the exploitation rates for specific chert categories, there are differences between the two periods. These differences emphasize again the dichotomy between recent terrace edge and central dune sites. Even small collections of early period flakes tend to contain all or most of the major types in the region (Figure 9-4), a pattern seen during the later period only in large collections. The ability of the exploitation potential model to explain overall chert frequencies suggests little or no change in the

Table 9-21. Frequency of Flakes Larger than 1/4 Inch by Raw Material, Dated and Sampled Sites.

Site	Period	Very Black	Gray-Blue-Brown	Red-Yellow	Franciscan	Other Chert	Fused Shale	Other	Total
SBa-706	Recent	307	27	19	9	28	0	3	393
SBa-980	Recent	491	63	2	0	5	0	2	563
SBa-998	Early	20	4	0	0	4	0	1	29
SBa-1038	Recent	67	20	5	0	12	0	0	104
SBa-1070	Recent	243	47	6	1	16	2	0	315
SBa-1070S	Recent	3	0	0	0	0	0	0	3
SBa-1170	Early	41	10	1	0	0	0	1	53
SBa-1174	Early	56	18	7	0	3	0	1	85
SBa-1177	Recent	4	3	1	0	0	0	0	8
SBa-1179	Recent	15	0	0	0	0	0	0	15
SBA-1180S	Early	22	16	3	0	0	0	0	41
SBa-1181	Recent	4	3	1	0	0	0	0	8
SBa-1718	Early	65	3	1	0	4	0	1	74
SBa-1036	--	101	18	5	3	31	0	0	158
SBa-1155	--	2	0	2	0	0	0	0	4
Totals		1441	232	53	13	103	2	9	1853

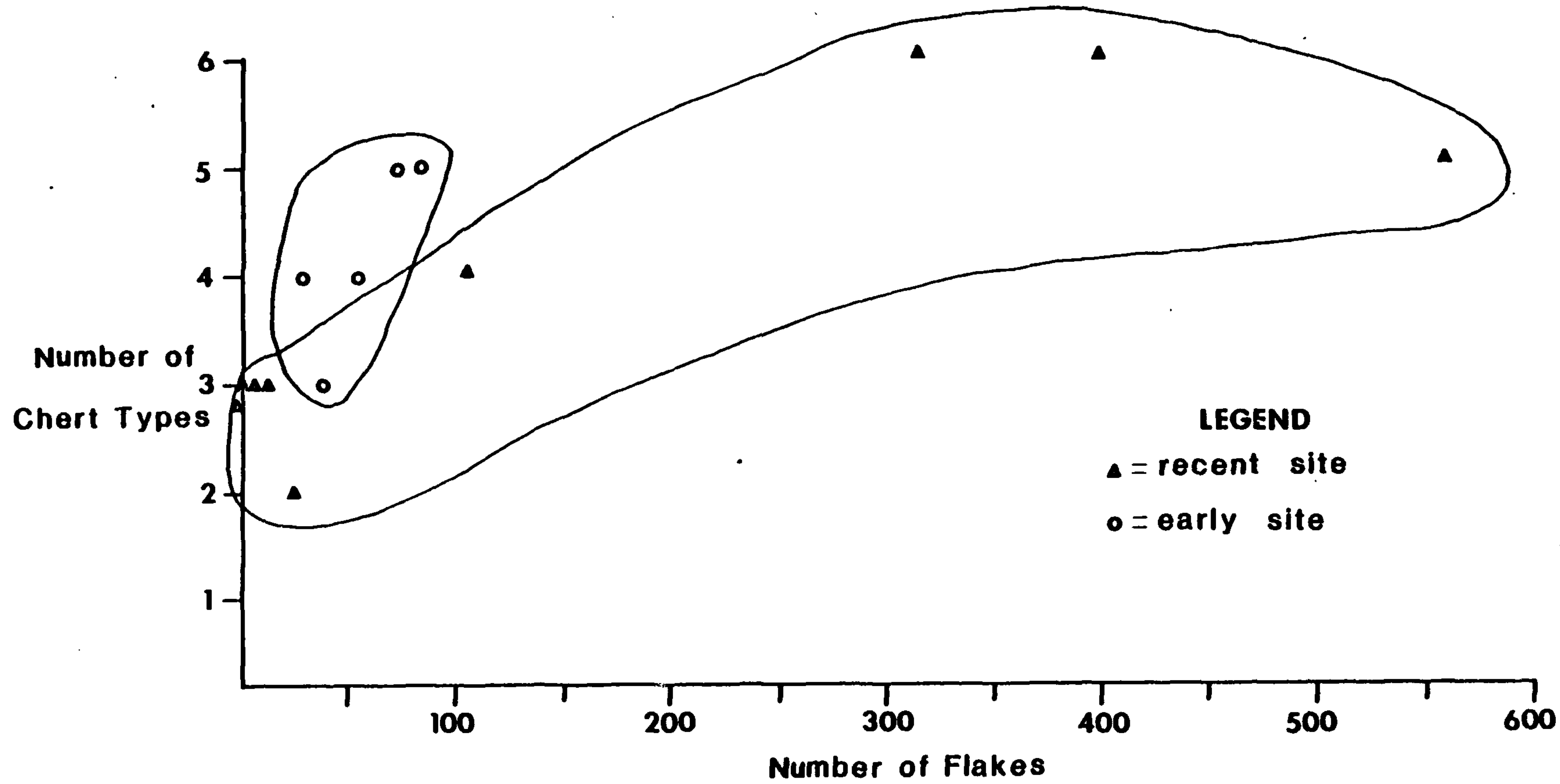

Figure 9-4. Number of Chert Types Plotted Against Number of Flakes by Site.

organization of chert procurement over time; the contrast presented in Figure 8-3 is probably another reflection of the dichotomy in site types in the recent material. Small groups traveling out from base camps for short trips would tend to take only a portion of the full range of materials available to them on any one trip, resulting in the pattern in the later collections of flakes. The homogeneity in this respect of the earlier sites is additional evidence for the simpler sites is additional evidence for the simpler site typology discussed in the previous section.

Examination of cortex frequencies should clarify this pattern. Table 9-22 shows the total number of corticated flakes by chert color and site, distinguishing between bedrock and cobble cortex. It is immediately apparent that these totals are very low even for very black chert, and hence cannot conclusively support detailed interpretations (the implications of these low totals are discussed in the Technology Section). The basic pattern which is visible is the relative abundance of bedrock cortex in the very black chert and the slightly higher frequency of cobble than bedrock cortex in gray-blue-brown chert. Bedrock chert is present on 5 percent of the very black flakes and 6 percent of the gray-blue-brown flakes; the comparable figures for cobble cortex are 0.7 percent and 8 percent, respectively. Comparing these patterns between periods and site types is pointless because of the tiny frequencies in all but the very black chert from recent terrace edge sites.

Primary reliance on bedrock or only slightly weathered very black chert suggests selection of raw material which is least likely to contain fractures which might cause manufacturing problems--cobbles which have been exposed on the beach for extended periods of time are probably poor candidates for reduction. This same assertion, however, should apply to gray-blue-brown chert, and cortex frequencies indicate a preference for cobble sources.

However, cobble and bedrock sources do not produce equal numbers of corticated flakes from comparably sized pieces. Internal bedrock fragments chosen at a quarry may have no cortex at all, and even those with cortex are likely to have it only on two faces. Cobbles, in contrast, have cortex over their entire surfaces. Bedrock sources also tend to produce largers clasts than cobble sources (see Chapter 8) which would further emphasize this disparity. The pattern in very black chert is made even clearer by this consideration, but the conclusion that cobbles of gray-blue-brown chert were preferred over bedrock sources is weakened.

The somewhat scanty data do suggest, however, that more gray-blue-brown than very black cobbles were used. If this interpretation is correct, the reasons for it are obscure. Bedrock gray-blue-brown outcrops contain a wider range of sizes of clasts than cobble sources, but the mean ranks of both types of source for both size and fracturing are nearly identical (see Chapter 8, Table 8-1) suggesting that, on the basis of average knapping characteristics, there is little to choose between them. Little more can be said without additional data.

Table 9-22. Corrected Number of Corticated Flakes by Cortex Type and Site.

Site	Period	Very Black bedrock	Very Black cobble	Gray-Blue-Brown bedrock	Gray-Blue-Brown cobble	Red-Yellow bedrock	Red-Yellow cobble	Other bedrock	Other cobble
SBa-706	Recent	8	2	3	5	-	2	0	0
SBa-930	Recent	32	2	2	0	-	0	0	0
SBa-1036		4	0	2	9	-	0	0	0
SBa-1033		3	0	0	1	-	0	0	0
SBa-1070	Recent	18	1	2	0	-	0	0	0
SBa-1155		0	1	2	0	-	0	0	0
SBa-1174	Early	2	2	2	4	-	1	0	0
SBa-1179	Recent	3	0	0	0	-	0	0	0
SBa-1718	Early	2	2	0	0	-	0	0	0
Totals		72	10	13	19	-	3	0	0

One possible explanation for the difference, that different artifacts were made of gray-blue-brown than of very black chert, is not supported by the available data. There is no discernible association between tool types and specific color categories, at least at the level of analysis allowed by the relatively small sample sizes available. Excluding projectile points and dividing the remainder of the collection into flake tools, bifaces, and unifaces produces completely random artifact frequencies by chert color category (Table 9-23: chi-square=5.4, df=8, .75 greater than p greater than .5, coefficient of contingency=.26). Artifact frequencies in all three categories parallel debitage frequencies. Projectile point frequencies by material differ from debitage frequencies, but there is no association of point types, classified simply as early and recent types to obtain adequate cell frequencies, and chert color categories (Table 9-24: chi-square=.71, df=3, .9 greater than p greater than .75, coefficient of contingency=.03).

Table 9-23. Frequency of Utilized Flakes and Retouched Tools Other than Projectile Points by Chert Color

	Very Black	Gray-blue-brown	Other Monterey	Franciscan	Totals
Flakes	37	13	5	3	58
Bifaces	10	4	0	0	14
Unifaces	6	0	0	0	6
TOTAL	53	17	5	3	78

Table 9-24. Frequency of Early and Recent Period Projectile Points by Chert Color

	Very Black	Gray-blue-brown	Other Monterey	Franciscan	Totals
Early	2	2	1	2	7
Recent	5	5	3	2	15
TOTAL	7	7	4	4	22

These data suggest that although certain raw material types were preferentially used, any raw material could be used to manufacture whatever was needed. The calculations supporting this conclusion, however, may be skewed by small samples in certain categories (such as the small number of unifaces in Table 9-23). This possibility is supported by considering the kind of raw material needed to manufacture a large biface: it must be available as relatively large, flat pieces or as fragments from which such pieces can be struck, which is generally not the case for local terrace outcrops or local Franciscan chert. Technological analysis may shed some light on this problem.

Technology

This section concentrates on two topics: 1) the kind(s) of artifacts manufactured in the study area, and 2) the stages of manufacture of these artifacts represented in the collection. The major source of technological information available is in the attributes of the sample of flakes subjected to intensive analysis. The variables which will be discussed here are maximum width and thickness, dorsal scar orientation, platform type, presence or absence of cortex on the platform, and presence or absence of cortex on the dorsal surface. Site-by-site summaries of the data used in this analysis are presented in Table 9-25. The almost complete absence of wear traces on the platforms of the flakes in the collection indicates that virtually all of them were removed during manufacture. The presence of preforms and finished bifaces and a high overall frequency of bifacial platforms imply that this manufacture was at least partially directed towards biface manufacture. This analysis, then, will treat biface manufacture as the baseline to which to compare the study collection; deviations from a priori expectations derived from this baseline will indicate alternative kinds of manufacture or the absence of certain stages in manufacture.

The limits put on this analysis by the data available are less severe than in some preceding sections, but they are present nonetheless. Primary among these is the number of dated sites with large enough samples of flakes to be included in the sampling program. The sites in the four general classes defined in earlier which were sampled are:

- Recent, terrace edge: SBa-706, SBa-980, SBa-1038, SBa-1070;
- Recent, intermediate dunes: SBa-1070E, SBa-1179;
- Early, terrace edge: SBa-1174;
- Early, intermediate dunes: SBa-1718;

The presence of a single site in these last two categories makes generalizations about them somewhat tenuous. As in preceding sections, all such generalizations are presented here as hypotheses requiring further testing.

Table 9-25. Frequencies of Flakes by Site and Platform Type, Presence of Dorsal and Platform Cortex, and Dimensions.

Table 9-25a. Platform Type.

Site	Absent	Unifacial	Bifacial	Unworked	Indeterminate	Total
706	287	22	54	9	13	385
980	247	77	227	3	4	560
1036	109	11	27	5	2	154
1038	77	7	15	3	2	104
1070	180	38	81	6	6	311
1070E	0	0	1	0	0	1
1155	3	1	1	0	0	5
1174	50	9	25	0	0	84
1177	1	0	0	0	0	1
1179	7	2	9	6	1	25
1180S	3	0	1	0	0	4
1718	52	3	13	0	5	73
Surface	64	7	25	7	4	107
TOTALS	1,080	177	479	39	37	1,814

Table 9-25b. Dorsal Cortex.

Site	Absent	Present	Total
706	365	20	385
980	525	35	561
1036	129	25	154
1038	88	16	104
1070	290	21	311
1070E	1	0	1
1155	5	0	5
1174	74	10	84
1177	1	0	1
1179	19	6	25
1180S	2	2	4
1718	69	4	73
Surface	80	27	107
TOTAL	1,560	151	1,814

Table 9-25c. Platform Cortex.

Site	Absent	Present	Total
706	383	2	385
980	549	12	561
1036	154	0	154
1038	104	0	104
1070	305	6	311
1070E	1	0	1
1155	5	0	5
1174	83	1	84
1177	1	0	1
1179	21	4	25
1180S	3	1	4
1718	73	0	73
Surface	103	4	107
TOTAL	1,681	30	1,814

Table 9-25d. Width, Thickness, and Dorsal Scar Orientation.

	Width		Tickness		Dorsal Scars		
Site	Mean	CV	Mean	CV	Mean	CV	n
706	16.7	54.9	4.0	106.3	11.4	157.0	385
980	14.7	48.7	2.4	70.3	14.2	136.5	561
1036	16.5	45.9	4.0	88.0	3.7	161.0	154
1038	16.4	48.2	3.7	72.7	7.7	167.1	104
1070	13.7	50.3	2.6	75.0	17.7	119.2	311
1070E	15.0	----	3.0	----	0.0	----	1
1155	22.2	58.7	9.0	77.5	30.0	145.3	5
1174	16.3	53.9	4.1	83.2	5.8	197.8	84
1177	33.0	----	8.0	----	105.0	----	1
1179	34.2	59.1	8.2	67.6	46.7	107.0	25
1180S	43.3	14.3	13.8	58.3	81.3	111.9	4
1718	15.6	39.4	2.9	64.6	12.8	142.1	73
Surface	32.4	49.5	9.4	67.7	34.8	109.5	107

The variety of chert sources represented by small numbers of flakes is also difficult to deal with. This analysis defines patterns on the basis of the collection as a whole, and then examines key variables by chert type to see if specific sources were used in different ways. The overwhelming dominance of very black chert in the collection implies that general patterns will be particularly relevant to the exploitation of that particular source.

Biface Technology: Callahan (1979) provides a useful model of biface production which forms the conceptual basis of this analysis. Although Callahan's work was stimulated by his interest in the production of fluted points, the general aspects of his discussion of the early stages of manufacture can be applied to all biface technologies. Unfortunately, the emphasis of his work is on the biface itself, rather than on the debitage produced. His specific hypotheses about artifact size and shape are therefore only occasionally relevant to this discussion. Rather, the general attributes of the stages he defines imply certain characteristics of the debitage produced which can be compared to characteristics of the study collection. He also illustrates a number of bifaces in various stages of manufacture which provide more detailed comparative data.

In addition, flaking debris from the experimental manufacture of an ovate biface from a beach cobble of very black Monterey chert provides a baseline for this analysis. Unfortunately, statistics derived from these experimental data cannot be treated as population parameters for detailed quantitative comparisons (see Stahle and Dunn 1982) because they represent the work of only a single knapper working with a single cobble. However, their general range of variation provides a basis for predictions which should be true if the collections from the study area are the remains of biface production. Deviation from these predictions should indicate production of other tools or the absence of some biface production stages.

Stages of Manufacture: Callahan discusses four stages of manufacture which are relevant here. These are:

Stage 1: Obtaining the blank. The blank may be a large flake struck from a very large core, or, as seems to be the case in the study area, a suitable cobble or chunk;

Stage 2: Initial edging. This preliminary set of flake removals creates an edge which is suitable for further reduction, either by strengthening the thin edges of a flake blank or removing the rounded edges of a cobble or chunk. Stage 2 flakes extend only part way across the biface and do not remove all of the cortex;

Stage 3: Primary thinning. In this stage, the biface is given a lenticular cross-section by striking flakes to the centerline, removing any remaining cortex;

Stage 4: Secondary thinning. Here the biface is given a flattened cross-section which allows the knapper to thin it successfully without making it to narrow. Stage 4 flakes extend more than half way across the biface.

These stages as presented here are not necessarily intended to represent breaks in the physical process of producing a biface, but rather serve as aids in organizing an analysis (see Muto 1971:48).

Progressing through these stages, Callahan (1979:30-31) notes that flakes become less variable in size and shape, more regularly spaced along the edge, and thinner. In addition to these explicitly presented trends, the frequency of cortex on the platform clearly must decrease dramatically after Stage 2, while that of cortex on the dorsal surface decreases somewhat at that point and approaches zero after Stage 3. A last trend in biface debitage which is commonly noted (see Frison and Bradley 1981:31-41, Newcomer 1971, Stahle and Dunn 1982) is a decrease in flake size in later stages of manufacture, particularly in the final stages.

These stages result in a thin biface which can be used as is or can be finished into whatever form is needed. Although Callahan does not discuss the final stages of manufacture in any detail, the overall trend in the debitage they produce simply continues the decreasing size and increasing standardization in shape. In the study area, finishing flakes are unlikely to be represented on site because they tend to be small enough to be moved by the wind. This discussion therefore concentrates on the earlier stages of manufacture.

Predictions: Stage 1, obtaining a blank, is indirectly discussed in the preceding section. In Callahan's terms, the choices in the study area are either a beach or terrace cobble, a bedrock fragment from a coastal outcrop which is essentially the same as a beach cobble, and inland bedrock fragments. Beach cobbles and coastal bedrock fragments are thin enough to serve directly as blanks, while inland bedrock sources can produce either thin tabular pieces suitable for biface reduction or large cores from which flakes would have to be struck to serve as blanks (see Callahan 1979:41-66). The possibility of differences in initial reduction strategies linked to different raw materials is discussed later in this section.

Rough estimates of the general distributions of flake measurements and other attributes for flakes from all stages of biface production after Stage 1 can be derived from the experimental data discussed above. Figures 9-5 and 9-6 show the frequency distributions of width and thickness for 246 experimental flakes. Table 9-26 shows the frequencies of platform cortex, dorsal face cortex, platform type, and dorsal scar orientation (this last variable is categorized as parallel = 0 to 3 degrees, not parallel = 35 to 180 degrees, and indeterminate). Overall, the experimental flakes show 1) a fairly high percentage of cortex; 2) frequent non-bifacial platforms on flakes on which platform type is identifiable; 3) a high percentage of cortex on platforms; and 4) predominantly parallel dorsal scars. In addition, the

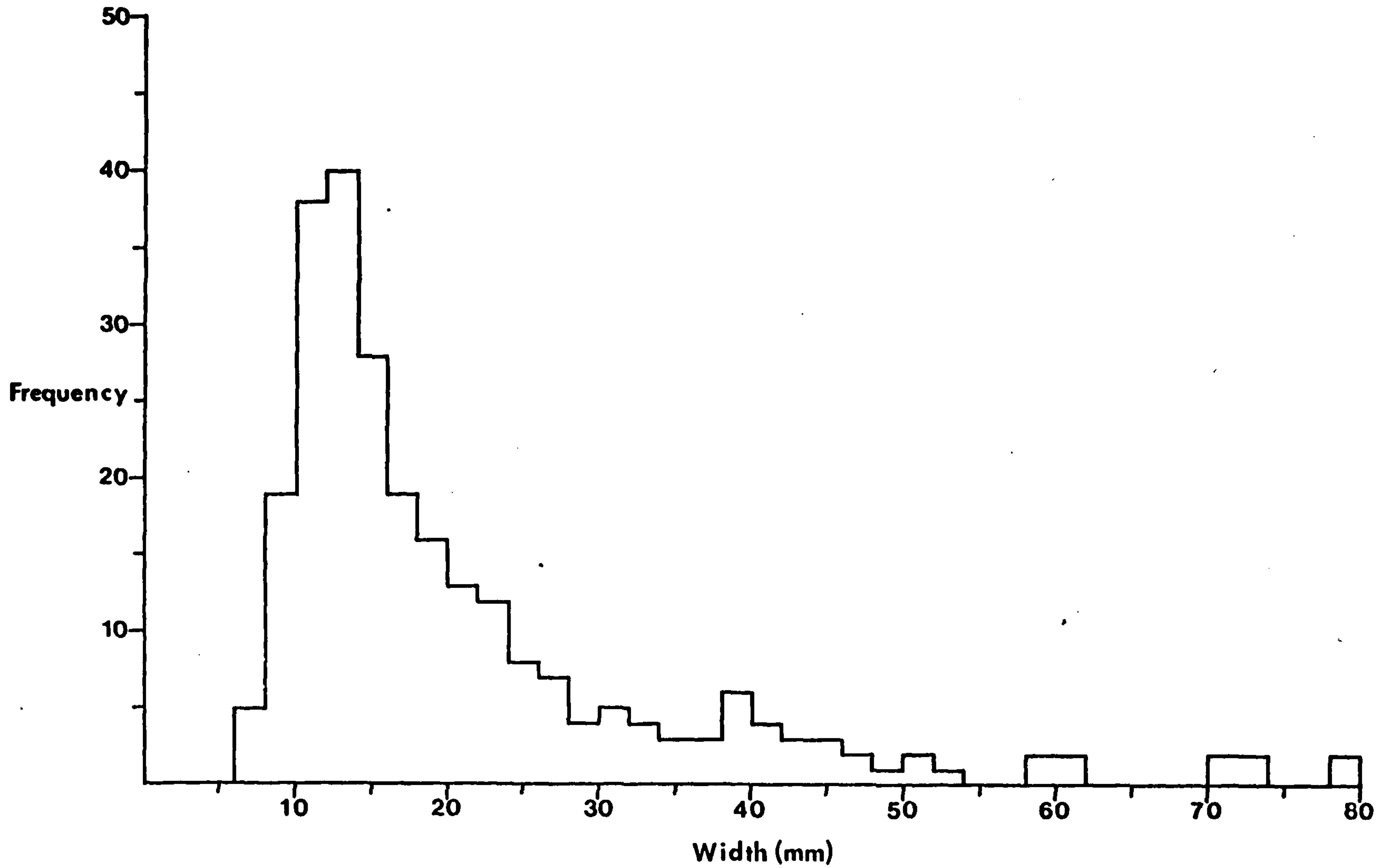

Figure 9-5. Histogram of Maximum Width Values for 246 Experimental Biface Reduction Flakes.

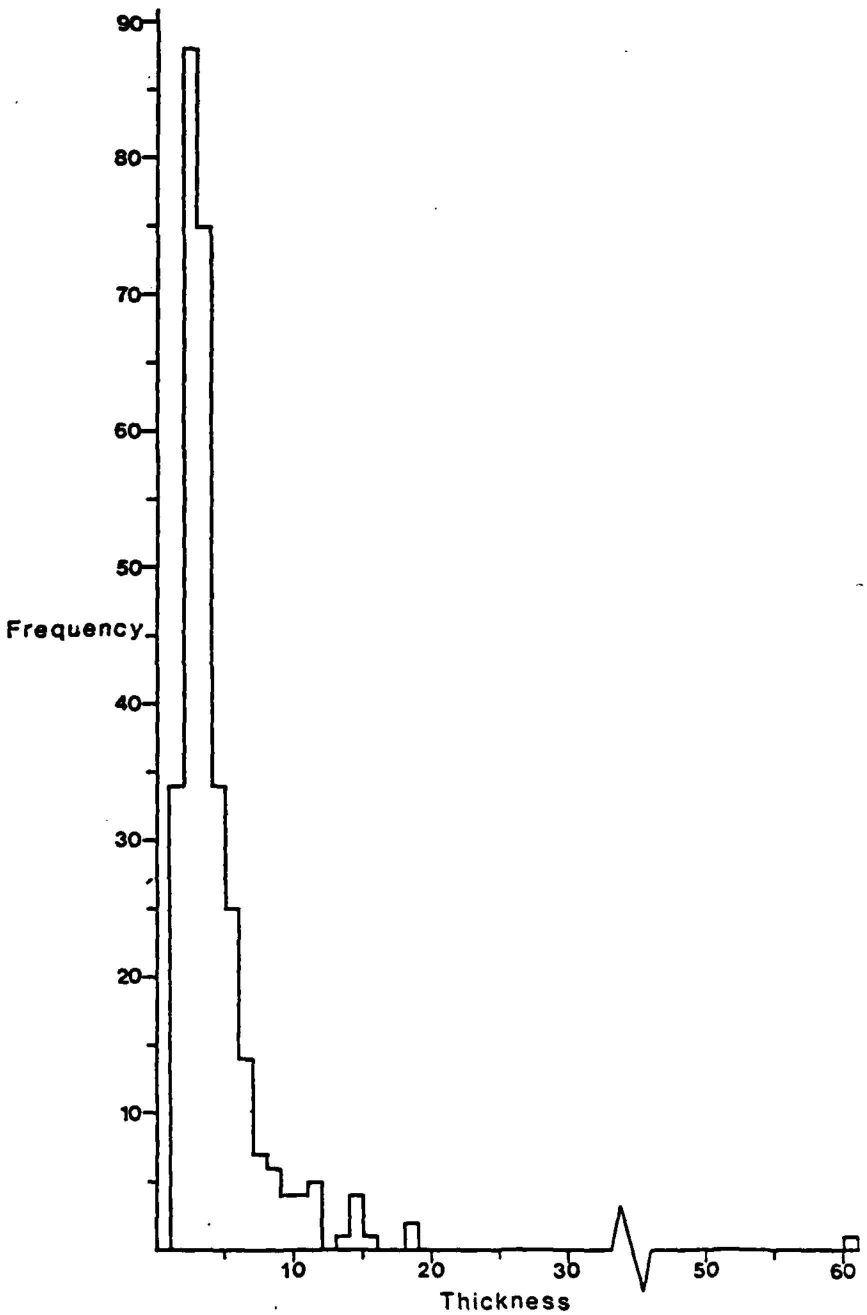

Figure 9-6. Histogram of Maximum Thickness Values for 246 Experimental Biface Reduction Flakes.

Table 9-26. Frequency of 1/4 Inch and 1/2 Inch Experimental Biface Production Flakes.

Variable	1/4 Inch	1/2 Inch	Total
cortex			
present	14	56	70
absent	94	82	176
platform type			
bifacial	26	34	60
unifacial	4	14	18
unworked	18	28	46
unidentifiable or absent	60	62	122
cortex on platform			
present	18	36	54
absent	32	41	73
platform absent	58	61	119
orientation of dorsal scars			
parallel	75	90	165
not parallel	22	22	44
indeterminate	11	26	37
	n=108	n=138	n=246

frequency distributions of flake width and thickness for this material (Figures 9-5 and 9-6) show smooth curves, heavily skewed to the right. These general characteristics should also be found in the study collection if it is biface production debris.

Some additional data are available on flake size distributions within the three stages defined above. Callahan (1979:69-82, 93-105, 119-138) illustrates experimentally produced bifaces in each stage at a scale of 1:1. This allows reasonably accurate measurements of flake scar size to be taken. These are summarized in Table 9-27, clearly showing the reduction in both flake size and variability in shape as the manufacturing sequence progresses.

Once again, it must be stressed that these values cannot be treated as population parameters for specific quantitative comparisons. However, the agreement between Callahan's 52 experiments and the single experiment using Monterey chert suggests that they can serve as a general baseline for comparison.

Table 9-27. Summary of Flake Width Measurements for Experimentally Produced Bifaces.

Stage	# bifaces n	mean	SD[a]	CV[b]	Measured
2	71	22.0	11.7	53.2	16
3	74	18.4	6.9	37.5	21
4	72	16.4	4.7	28.7	15
overall	221	18.9	11.6	61.4	52
other, experimental[c]	246	18.8	13.9	73.9	1

[a] standard deviation

[b] coefficient of variation

[c] experimental with Monterey chert; see text.

These data allow a somewhat more rigorous set of predictions to be made. If all stages of biface production are present:

1. Width and thickness values should show smooth frequency distributions which are strongly skewed to the right (see Figure 9-5). Dorsal scar values should cluster near zero, producing a similar distribution.

2. The flakes should show high percentages of dorsal face cortex (at least 25 percent) and platform cortex (possibly as high as 40 to 50 percent of the identifiable platforms).

3. There should be fairly high frequencies of non-bifacial platforms (possibly as high as 50 percent of the identifiable platforms), particularly of unworked platforms struck off during Stage 2 reduction.

4. A high degree of variability in maximum width measurements (coefficient of variation (CV roughly 60 to 80 percent). The coefficient of variation (Thomas 1976:82-83) will be used to measure variability, rather than the standard deviation, to allow for the possibility of systematic differences between core sizes and hence flake sizes among different portions of the study collection and between archaeological and experimental material. These differences could arise as a result of cultural selection for specific sizes or because of differing size ranges in chert available to experimenters and the prehistoric inhabitants of the study area.

5. A wide range of dorsal scar orientation, maximum width, and maximum thickness values. In the experimental examples, widths as high as 78 mm and thicknesses as high as 78 mm were recorded.

If only late production stages are present:

1. The first prediction should still be true.

2. Dorsal cortex frequencies should be low, and platform cortex frequencies should be very low.

3. The frequency of bifacial platforms should be high, and that of unworked platforms should be very low.

4. Variability in width measurements should be moderate (CV = 30 to 60).

5. The range of dorsal scar, width, and thickness values should be relatively narrow. The maximum flake width recorded on Callahan's Stage 3 and 4 bifaces was 35 mm.

It is also possible that other kinds of chipped stone artifacts were manufactured in the study area. The major alternative strategy to biface production which might be represented in the collection is one oriented towards producing flakes for use as tools. If this activity were carried out:

1. Frequency distributions for length and width should show a concentration of small flakes produced during platform preparation and production failures, but also a normal or nearly normal distribution of larger flakes, representing broken or otherwise unsuitable flakes which were the rejected end-products of core reduction.

2. Frequency distributions of dorsal scar values should show more variability, as flake production procedures (other than classic blade technologies) tend to be more opportunistic than biface production procedures and hence to produce less standardized forms (see Callahan 1979:53).

Analysis

This is the one section of the analysis for which the sampling program was not completely appropriate, because the unequal sampling fractions taken to record technological variables on 1/4 inch and 1/2 inch flakes result in an overrepresentation of large flakes. This means that computations of flake size in the collection will result in slight overestimations of the actual values. For recent terrace edge sites, there are 202 extra 1/2 inch flakes (13.7 percent of all flakes from these sites), for recent intermediate dune sites there are 2 extra flakes (13.3 percent of the total), for early terrace edge sites 12 extra flakes (15.2 percent of the total), and for early intermediate dune sites 8 extra flakes (10.8 percent of the total).

Although this problem should be kept in mind throughout this section, it does not invalidate this analysis for several reasons. First, no probabilistic comparisons of expected and recovered flake sizes are made as was noted above. The predictions outlined above are based primarily on variability in flake sizes, not on absolute sizes, and rely on the coefficient of variation (CV) rather than the standard deviation. The CV is computed to be independent of absolute measurements (Thomas 1976:82-83). The inflation of CVs computed on the study collection should be minimal because of the low percentage of the whole made up by the extra large flakes and because, as is shown below, small flakes are not much more abundant than large flakes. Second, the analysis is only partially based on flake size; other variables are equally or more important.

Figure 9-7 through 9-10 show the frequency distributions of flake width, thickness, and dorsal scar orientation in the study collection by site types within each period. (Site-by-site totals for all technological variables are presented in Table 9-28). Only in the case of recent central dune sites is there a deviation from the smooth, right-skewed distribution predicted for biface manufacture. This deviation is clearly due to the relatively large numbers of used flakes present at these sites; the distributions of unused flakes are similar to those at the other sites. This suggests that the debitage in all sites is the result of biface manufacture.

This interpretation is also consistent with the data on the other variables considered here. Tables 9-29 and 9-30 show the percentages of platform types and dorsal and platform cortex by site type and period. All four classes of sites, including recent central dune sites when only unused flakes are considered, conform to the predictions for biface production based on the absence of earlier stages of manufacture. They show a high percentage of bifacial platforms, a very low percentage of unworked platforms and platform cortex (without the used flakes, the recent central dune sites have 0% of unworked platforms and platform cortex), and low frequencies of dorsal cortex. The near absence of unworked platforms and platform cortex is particularly clear evidence that unworked cobbles were not brought into the study area and completely reduced there. The relatively high rates of dorsal cortex on recent central dune and early terrace edge sites are due to high cortex frequencies on, respectively, used flakes and gray-blue-brown flakes. The implications of these rates are discussed below.

Similarly, the width, thickness, and dorsal scar values (Figures 9-9, 9-10; Table 9-31) tend to lack the maximum values expected in the full manufacturing sequence. The variability in maximum width measurements is also less than that seen experimentally. The very high degree of variability in thickness and dorsal scar measurements is interesting, and is probably caused by two factors. The first is the combining of debitage from all manufacturing stages carried out in the study collection for this analysis (see Table 9-27). The second is that thickness may not be a very useful indicator of early and intermediate manufacturing stages because it varies within such narrow limits. In any case, the means for these variables show consistently thin flakes and consistently parallel flake scars, both of which indicate later stages of manufacture.

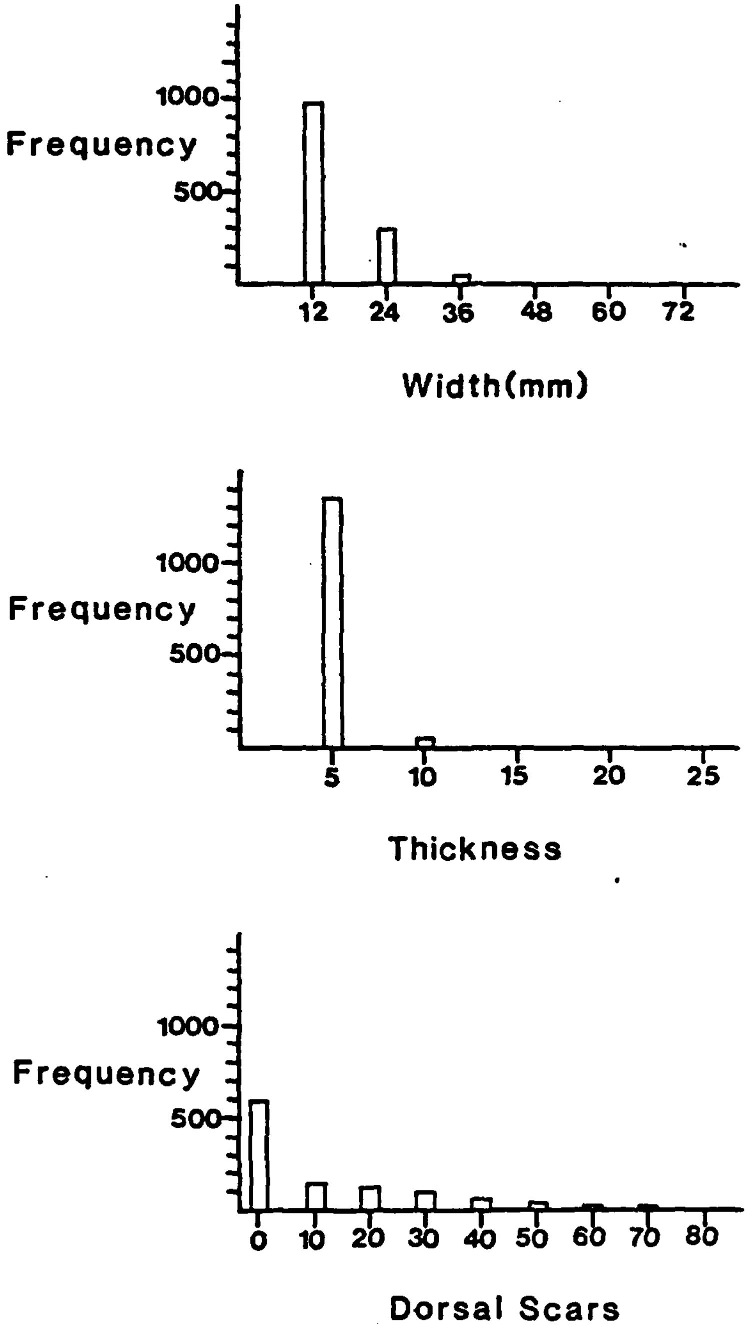

Figure 9-7. Histograms of Width, Thickness, and Dorsal Scar Orientation Values for Recent Terrace Edge Sites.

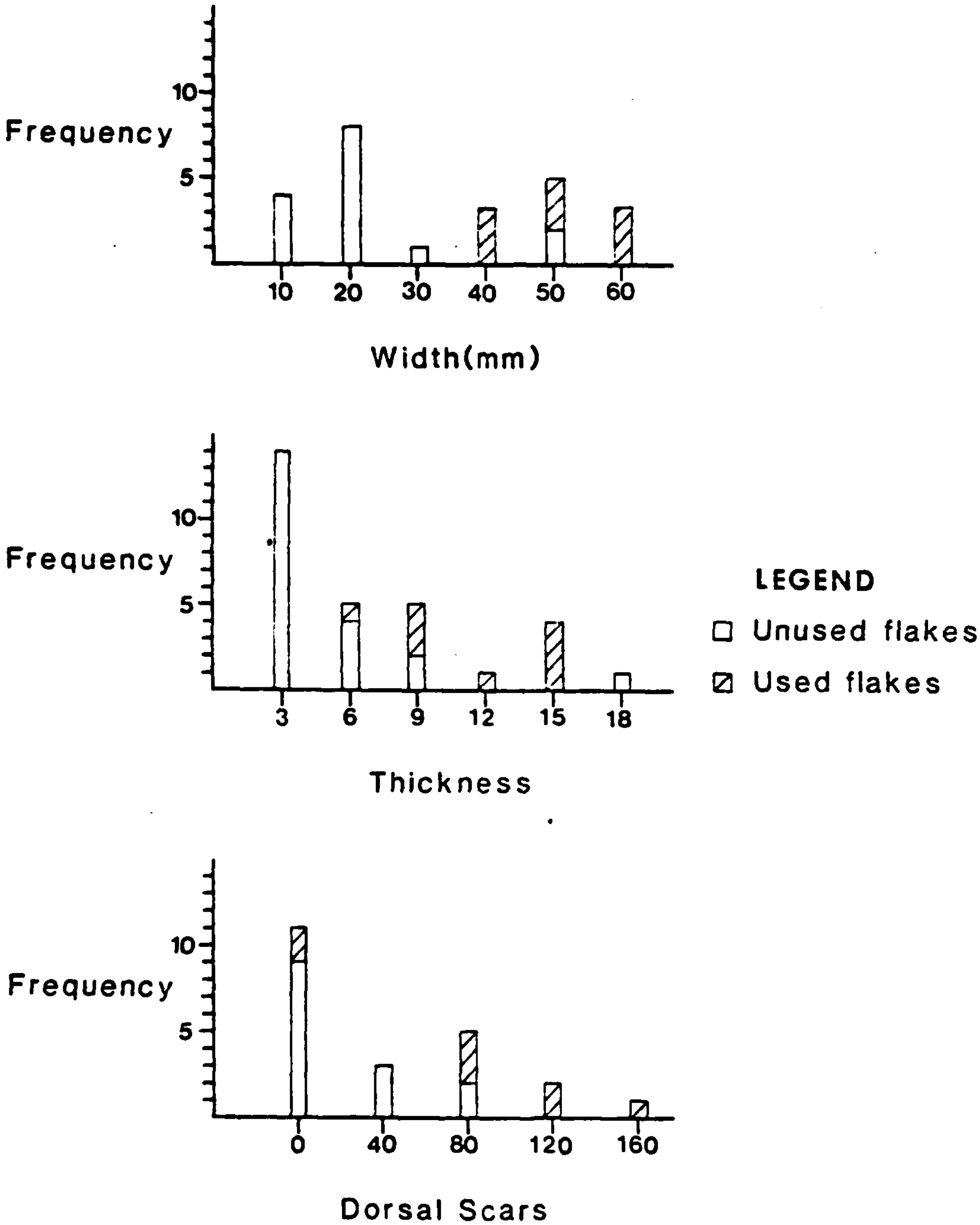

Figure 9-8. Histograms of Width, Thickness, and Dorsal Scar Orientation Values for Central Dune Sites.

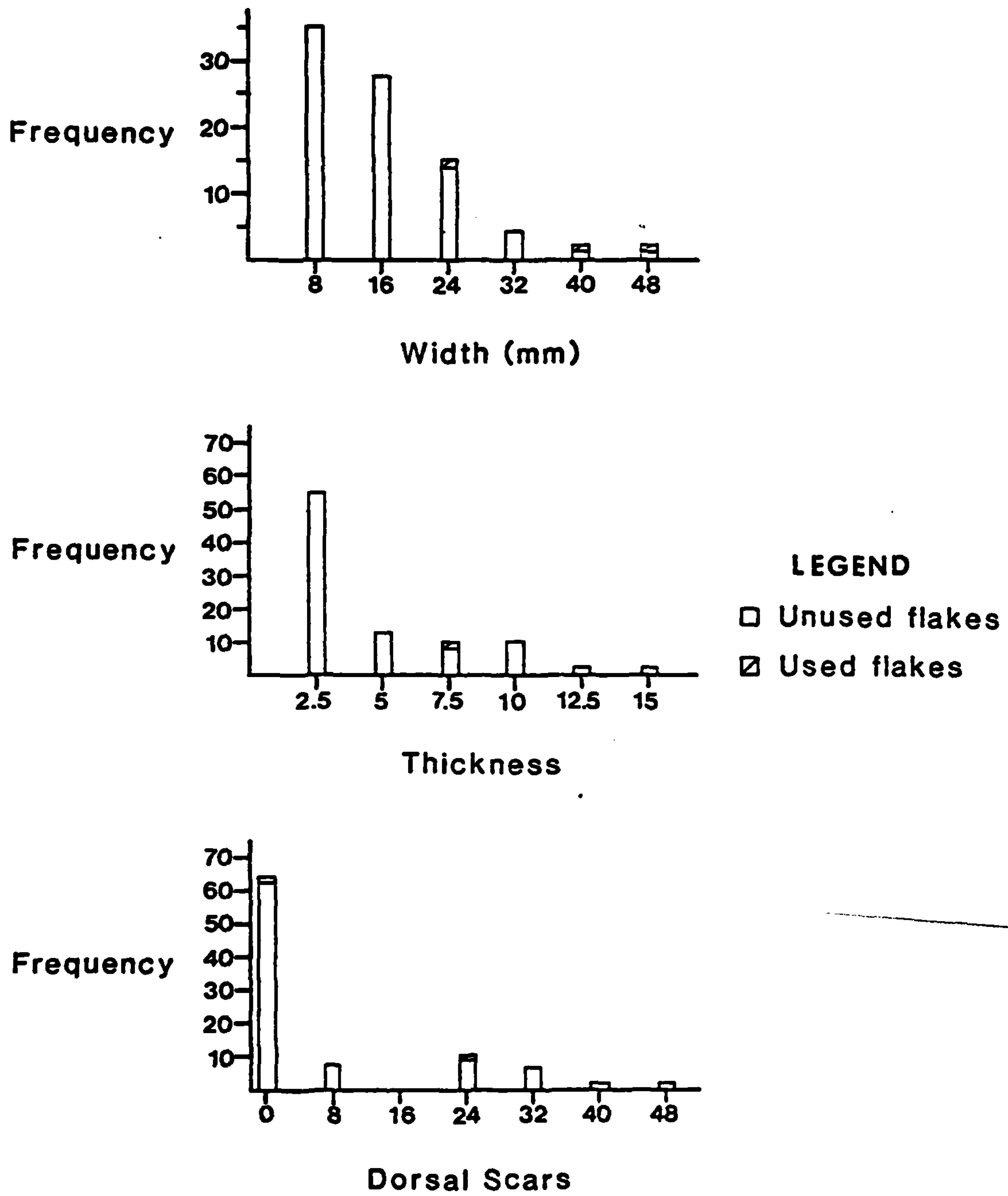

Figure 9-9. Histograms of Width, Thickness, and Dorsal Scar Orientation Values for Early Terrace Edge Sites.

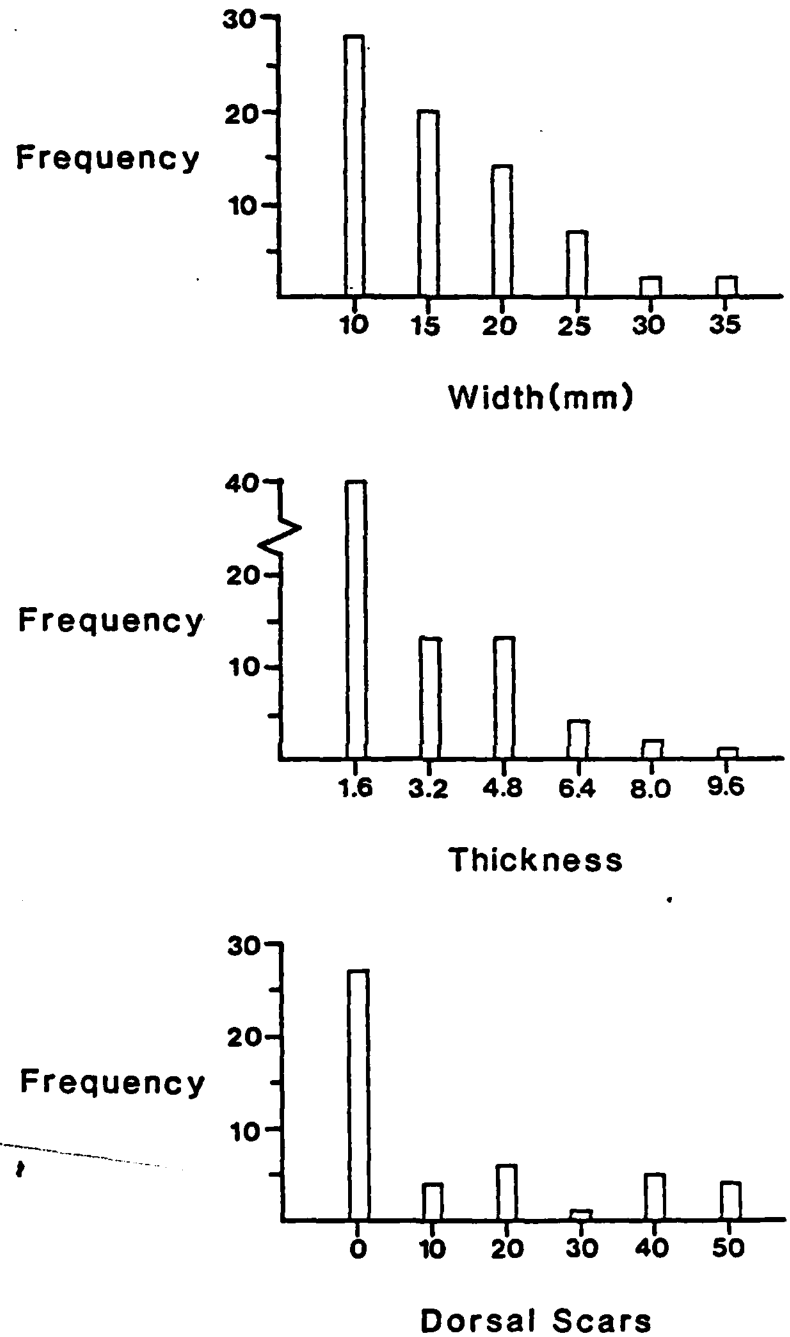

Figure 9-10. Histograms of Width, Thickness, and Dorsal Scar Orientation Values for Early Central Dune Sites.

Table 9-28. Site-by-Site Summaries of Flake Frequencies and Measurements.

Table 9-28a. Platform Type.

Site	Absent	Unifacial	Bifacial	Unworked	Indeterminate	Total
706	287	22	54	9	13	385
980	247	77	227	3	4	560
1036	109	11	27	5	2	154
1038	77	7	15	3	2	104
1070	180	38	81	6	6	311
1070E	0	0	1	0	0	1
1155	3	1	1	0	0	5
1174	50	9	25	0	0	84
1177	1	0	0	0	0	1
1179	7	2	9	6	1	25
1180S	3	0	1	0	0	4
1718	52	3	13	0	5	73
Surface	64	7	25	7	4	107
TOTALS	1,080	177	479	39	37	1,814

Table 9-28b. Dorsal Cortex.

Site	Absent	Present	Total
706	365	20	385
980	525	35	561
1036	129	25	154
1038	88	16	104
1070	290	21	311
1070E	1	0	1
1155	5	0	5
1174	74	10	84
1177	1	0	1
1179	19	6	25
1180S	2	2	4
1718	69	4	73
Surface	80	27	107
TOTAL	1,560	151	1,814

Table 9-28c. Platform Cortex.

Site	Absent	Present	Total
706	383	2	385
980	549	12	561
1036	154	0	154
1038	104	0	104
1070	305	6	311
1070E	1	0	1
1155	5	0	5
1174	83	1	84
1177	1	0	1
1179	21	4	25
1180S	3	1	4
1718	73	0	73
Surface	103	4	107
TOTAL	1,681	30	1,814

Table 9-28d. Width, Thickness, and Dorsal Scar Orientation.

	Width		Thickness		Dorsal Scars		
Site	Mean	CV	Mean	CV	Mean	CV	n
706	16.7	54.9	4.0	106.3	11.4	157.0	385
980	14.7	48.7	2.4	70.3	14.2	136.5	561
1036	16.5	45.9	4.0	88.0	3.7	161.0	154
1038	16.4	48.2	3.7	72.7	7.7	167.1	104
1070	13.7	50.3	2.6	75.0	17.7	119.2	311
1070E	15.0	----	3.0	----	0.0	----	1
1155	22.2	58.7	9.0	77.5	30.0	145.3	5
1174	16.3	53.9	4.1	83.2	5.8	197.8	84
1177	33.0	----	8.0	----	105.0	----	1
1179	34.2	59.1	8.2	67.6	46.7	107.0	25
1180S	43.3	14.3	13.8	58.3	81.3	111.9	4
1718	15.6	39.4	2.9	64.6	12.8	142.1	73
Surface	32.4	49.5	9.4	67.7	34.8	109.5	107

Table 9-29. Percent of Identifiable Platform Types by Site Type and Period.

Site Type	percent bifacial	percent unifacial	percent unworked	n[a]
Recent				
terrace edge	70	26	4	542
central dunes	47	13	40	15
Early				
terrace edge	74	26	0	34
central dunes	82	19	0	16

n[a] = number of identifiable platforms

Table 9-30. Percent of Dorsal and Platform Cortex by Site Type and Period.

Site Type	percent dorsal cortex	percent platform cortex	n[a]
Recent			
terrace edge	6	2	1,360
central dunes	16	17	26
Early			
terrace edge	12	1	84
central dunes	5	0	73

Table 9-31. Variability in Flake Width, Thickness and Dorsal Scar Orientation by Site Type.

Site Type	width mean	width range	width CV	thickness mean	thickness range	thickness CV	dorsal scars mean	dorsal scars range	dorsal scars CV
Recent									
terrace edge	15.2	84 (57)[b]	51.8	3.0	34 (28)	96.1	13.8	95 (90)	139.0
central dunes	34.1	60 (44)	59.5	8.2	19 (19)	67.6	44.2	180 (130)	112.4
Early									
terrace edge	16.3	40 (38)	53.9	4.1	14 (14)	83.2	5.8	50 (50)	197.7
central dunes	15.6	28 (28)	39.4	2.9	9 (9)	64.6	12.8	60 (60)	142.1

a = coefficient of variation
b = range without used flakes

There are, however, systematic differences between recent and early collections. Flakes from early sites tend to have less frequent platform cortex and show substantially narrower ranges of variation in width, thickness, and dorsal scar orientation than do those in recent sites. The size difference may be partially due to wind removal of the very smallest 1/4 inch flakes over the longer period of time these sites have been exposed, but as Table 9-32 shows, the range of variation is also restricted at the upper limits. Furthermore, wind-sorting cannot account for the other differences. This pattern of platform cortex frequencies and variability in size and dorsal scar orientation indicates that the debitage from early sites represents a generally later stage of biface production than does the debitage from recent sites.

These patterns can be phrased in terms of Callahan's stages discussed earlier. The nearly complete absence of platform cortex and low frequency of dorsal cortex relative to the experimental data indicate that Stage 2 manufacture was not carried out in the study area. The recent debitage appears to be the result of Stage 3 and later knapping. The early debitage's lower cortex frequencies, especially platform cortex, and relatively narrower range of variation in flake size and dorsal scar orientation probably indicate that somewhat more finished bifaces, probably ready for Stage 4, were brought into the study area.

The few preforms which are complete enough to measure also suggest Stage 2 bifaces were brought into the terrace during recent times. Callahan (1979:10, 18, 30, 67) notes that Stage 2 bifaces characteristically have width/thickness ratios from 2.00 to 3.00. In later stages, this ratio increases. The four preforms which can be reliably measured have ratios of 2.52, 2.84, 1.92, and 1.8. The lowest value is on the only complete preform in the collection, recovered from SBa-1179. Deep step scarring and several flakes which can be refitted to this artifact show that it was discarded after unsuccessful attempts to remove a lump from its proximal end; its original width/thickness ratio was probably somewhat higher.

<u>Variation by Raw Material</u>: Tables 9-33 through 9-35 show the frequencies of platform types, platform cortex, and dorsal cortex for the four major varieties of chert by site type. Tables 9-36 through 9-38 show mean values and variability for width, thickness, and dorsal scar orientation for the same classes. Overall, the similarities between all reasonably large classes of flakes for all of these variables far outweigh the differences. The only differences which may be meaningful are:

- Yellow/red laminated flakes have a narrower range of width values than any other set of flakes;

- Very black flakes in recent terrace edge sites have a wider range of thickness than do other flakes;

Table 9-32. Five Maximum and Five Minimum Values of Flake Width, Thickness, and Dorsal Scar Orientation by Site Type.

Site Type	width max.	width min.	thickness max.	thickness min.	dorsal scars max.	dorsal scars min.
Recent, terrace edge	50	4	24	1	90	0
	53	4	26	1	90	0
	61	4	27	1	90	0
	61	4	29	1	90	0
	88	5	35	1	95	0
Recent, central dunes	50	9	15	2	60	0
	53	11	15	2	70	0
	64	14	15	3	100	0
	69	14	16	3	130	0
	69	15	21	3	180	10
Early, terrace edge	35	7	11	1	30	0
	36	7	11	1	30	0
	38	7	12	1	40	0
	45	7	12	1	40	0
	47	7	15	1	50	0
Early, central dunes	25	7	7	1	40	0
	28	7	7	1	50	0
	30	8	8	1	50	0
	34	8	8	1	50	0
	35	9	10	1	60	0

Table 9-33. Platform Types for Chert Varieties by Site Type.

Site Type	percent bifacial	percent unifacial	percent unworked	n*
Recent, terrace edge				
very black	71	25	4	449
gray-blue-brown	64	33	3	72
yellow/red laminated	72	14	14	7
other chert	50	43	7	14
Recent, central dunes				
very black	38	15	46	13
gray-blue-brown	0	100	0	1
yellow/red laminated	--	--	--	0
other chert	--	--	--	0
Early, terrace				
very black	67	33	0	24
gray-blue-brown	83	17	0	6
yellow/red laminated	100	0	0	3
other chert	100	0	0	1
Early, central dunes				
very black	80	20	0	15
gray-blue-brown	100	0	0	1
yellow/red laminated	--	--	--	0
other chert	--	--	--	0

*number of identifiable platforms.

Table 9-34. Platform Cortex for Chert Varieties by Site Type.

Site Type	precent present	percent absent	n*
Recent, terrace edge			
very black	2	98	1,109
gray-blue-brown	5	95	160
yellow/red laminated	1	99	30
other chert	0	100	61
Recent, central dunes			
very black	19	81	21
gray-blue-brown	--	--	0
yellow/red laminated	0	100	1
other chert	--	--	0
Early, terrace			
very black	1	99	56
gray-blue-brown	0	100	18
yellow/red laminated	0	100	7
other chert	0	100	3
Early, central dunes			
very black	0	100	65
gray-blue-brown	0	100	3
yellow/red laminated	0	100	1
other chert	0	100	4

*total number of flakes.

Table 9-35. Percent of Dorsal Cortex for Chert Categories by Site Type.

Site Type	percent cortex	percent no cortex	n*
Recent, terrace edge			
very black	6	94	1,108
gray-blue-brown	8	92	157
yellow/red laminated	7	93	32
other chert	0	100	61
Recent, central dunes			
very black	21	79	23
gray-blue-brown	100	0	1
yellow/red laminated	--	0	0
other chert	--	--	0
Early, terrace			
very black	7	93	56
gray-blue-brown	33	67	18
yellow/red laminated	14	86	7
other chert	0	100	3
Early, central dunes			
very black	6	94	65
gray-blue-brown	0	100	3
yellow/red laminated	0	100	1
other chert	0	100	4

*total number of flakes.

Table 9-36. Flake Width by Chert Category and Site Type.

Site Type	mean	range	CV*	n
Recent, terrace edge				
very black	15.2	84	50.6	1,110
gray-blue-brown	15.3	56	60.6	160
yellow/red laminated	12.9	15	49.3	30
other chert	14.8	41	48.3	61
Recent, central dunes				
very black	33.7	60	61.0	21
gray-blue-brown	44.0	--	--	1
yellow/red laminated	--	--	--	0
other chert	--	--	--	0
Early, terrace				
very black	16.6	40	58.3	56
gray-blue-brown	14.7	17	38.6	18
yellow/red laminated	17.1	26	53.8	7
other chert	19.0	16	43.1	3
Early, central dunes				
very black	15.4	28	36.7	65
gray-blue-brown	10.3	3	14.8	3
yellow/red laminated	14.0	--	--	1
other chert	23.3	24	46.8	4

*coefficient of variation.

Table 9-37. Flake Thickness by Material and Site Type.

Site Type	mean	range	CV*	n
Recent, terrace edge				
very black	2.9	34	94.6	1,110
gray-blue-brown	2.8	19	93.4	160
yellow/red laminated	4.3	18	114.8	30
other chert	4.0	15	91.7	61
Recent, central dunes				
very black	8.1	19	69.8	21
gray-blue-brown	10.0	--	--	1
yellow/red laminated	--	--	--	0
other chert	--	--	--	0
Early, terrace				
very black	3.5	11	82.4	56
gray-blue-brown	4.0	14	96.6	18
yellow/red laminated	7.6	7	47.5	7
other chert	6.7	8	62.5	3
Early, central dunes				
very black	2.9	9	64.0	65
gray-blue-brown	1.3	1	43.3	3
yellow/red laminated	5.0	--	--	1
other chert	4.3	6	58.8	4

*coefficient of variation.

Table 9-38. Dorsal Scar Orientation by Material and Site Type.

Site Type	mean	range	CV*	n
Recent, terrace edge				
very black	14.0	95	140.2	1,110
gray-blue-brown	13.4	90	134.4	160
yellow/red laminated	14.4	60	116.9	30
other chert	10.8	40	129.7	61
Recent, central dunes				
very black	43.5	180	114.0	21
gray-blue-brown	100.0	--	--	1
yellow/red laminated	--	--	--	0
other chert	--	--	--	0
Early, terrace				
very black	6.6	50	192.1	56
gray-blue-brown	3.9	30	235.7	18
yellow/red laminated	4.3	20	183.6	7
other chert	6.7	20	173.2	3
Early, central dunes				
very black	12.6	60	142.3	65
gray-blue-brown	0.0	0	--	0
yellow/red laminated	--	--	--	0
other chert	23.3	50	107.9	4

*coefficient of variation.

- Gray-blue-brown flakes from early terrace edge sites (i.e., from SBa-1174) have substantially more frequent dorsal cortex than do any other group of flakes.

None of these patterns suggests any radical differences in technological patterns. The first can be accounted for by the generally small size of the cobbles available on the south edge of Burton Mesa (see Chapter 8). The second may be no more than the result of random factors in combination with large variation in sample sizes.

The third deviation is particularly interesting in light of the unusually high proportion of gray-blue-brown chert at SBa-1174 (see Quarry Use Section). As was noted earlier, this site is closer to the source of this chert than any other in the sample. All other variables are consistent with those expected for biface manufacture; the high dorsal cortex frequency suggests that earlier stages of this manufacture were carried out there. This possibly implies that gray-blue-brown chert was procured on trips originating at this site. However, the lack of other sites on the north of the terrace and the small number of flakes involved here make this interpretation fairly tenuous.

The overall similarity of all the chert varieties suggests that bifaces of all materials were brought to the study area in comparable stages of manufacture and that the generalizations above need not be modified (although better samples of several of the chert types may modify this conclusion). The study of earlier stages of manufacture, including distinguishing different types of biface blanks selected in Stage 1, requires information from outside of the study area.

Used Flakes: All of the used flakes appear to have been selected from the biface production flakes; many of them appear to have been selected from Stage 2 biface flakes. Only in the case of the widths of three flakes do they exhibit a range of variation which has not been experimentally reproduced in the biface production flakes analyzed here (Figure 9-7; Table 9-39). On all variables, however, they show distinctly different frequency distributions.

Both width and thickness values approximate a slightly skewed normal distribution (Figure 9-11) with a central tendency well above that of the unused flakes. This is the distribution expected if the flakes were chosen on the basis of some predetermined standard of size from a highly skewed population such as that of the biface flakes. Dorsal scar orientation, dorsal cortex, platform type, and platform cortex all suggest that these flakes tended to be selected from an early stage of production, probably Stage 2. This is indicated by the high frequencies of non-parallel dorsal scars and cortex, and particularly by the extremely high frequencies of platform cortex and unworked platforms. Stage 2 biface flakes, unlike those from any other stage, are particularly characterized by these last two traits.

If this hypothesis is correct and if Stage 2 reduction did not occur in the study area, as was discussed above, then many of the flakes used as tools must have been produced and selected elsewhere and brought into the San Antonio Terrace as flakes. The absence of other evidence for the initial stage of biface manufacture is inconsistent with the alternative hypothesis that they were produced in situ.

Table 9-39. Frequencies of Dorsal Cortex, Platform Cortex, and Platform Type for Used Flakes.

	number	percent
dorsal cortex:		
present	18	49
absent	19	51
platform cortex:		
present	9	38[a]
absent	15	62
no platform	13	--
platform type:		
bifacial	10	46[a]
unifacial	3	14
unworked	9	41
absent	12	--

[a]percent computed only on basis of identifiable platforms.

This conclusion is somewhat unexpected. Field examinations by this author of several sites on the terrace adjacent to the beach revealed fairly frequent multi-directional flake cores made on spherical to flat beach cobbles of very black chert. It is possible that the inability here to differentiate used flakes from biface reduction flakes on the basis of their mode of production simply reflects the small number of the former relative to the latter and/or the likely use of both specially manufactured flakes and flakes selected from biface production debris as tools.

However, no cores such as those just described were recovered in the excavations which produced the collections discussed here, and no sites in the area where such cores were noted were excavated. There may be spatial variation in the technology used on the terrace which is related to ease of access to the villages at the coastal outcrops. The most direct route from, for instance, Purisima Point to the San Antonio Terrace is straight up the beach. Unfortunately, this study includes no data on which to test this possibility.

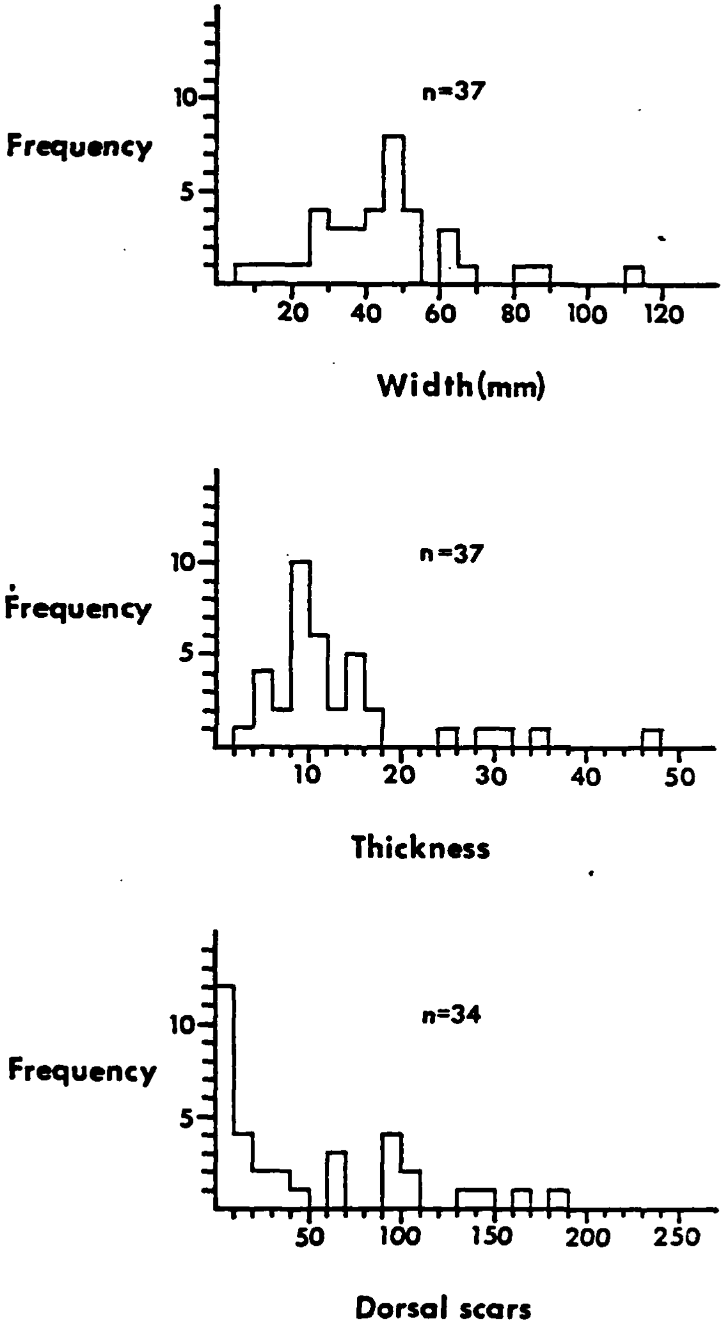

Figure 9-11. Histograms of Width, Thickness, and Dorsal Scar Orientation Values for Used Flakes.

To summarize, the data suggest that virtually all of the debitage recovered from the study area was produced in biface manufacture. However, neither the recent nor the early flakes appear to have been removed during the earliest stages of production; this work was apparently completed elsewhere. During the early period, bifaces were introduced to the terrace as completely flaked, lenticular forms (Callahan's completed Stage 3). During recent times, they were introduced as roughly edged, incompletely flaked pieces (Callahan's completed Stage 2). The decreased amount of retouch needed to finish a Stage 3 biface explains the lower flake densities in all earlier than in recent terrace edge sites. It also explains the absence of preforms in early sites; Callahan (1979:68) notes that only when Stage 3 is completed is it possible to be confident that flaws in the raw material will not cause breakage. The flakes used as tools tentatively appear to have been selected for use from the Stage 2 flakes produced when the bifaces were initially manufactured, probably outside the study area.

Summary and Conclusions

The interpretations discussed here are presented as hypotheses which are in need of more rigorous test. Both the sample of sites on the terrace which were investigated and the structure of the investigations were non-random, and the samples of artifacts collected were frequently small. Although the patterns which have been identified here can legitimately be said to characterize the material which was collected, whether that material is representative of the actual situation on the terrace is an open question which can be answered only by additional fieldwork. The reconstruction offered here should provide an explicit basis for such fieldwork.

The sites discussed here can be dated to pre- and post- A.D. 500. Human activity in the study area during these two periods appears to have been directed towards the procurement of similar resources, but the organization of this procurement appears to have changed through time.

Collections from all sites in the study area are dominated by tools used to procure and process large game. This activity seems to have taken place in all parts of the terrace. However, non-procurement and processing activities show differing distributions during the two periods. During recent times, tools used for maintenance activities, debitage from tool manufacture, and evidence for projectile point retooling are all found mainly within 1,000 m of the terrace edge. This suggests that sites closer to the terrace edge are small-scale base camps while sites within the central portion of the intermediate dunes are extremely temporary and use-specific. The distribution of non-processing tools in early sites may be similar to this, but debitage frequencies and projectile point distributions do not vary systematically. This implies that the recent period dichotomy between base and special use camps is weakly developed at best during the early period, particularly because SBa-1174, where most early period maintenance tools were found, is not strictly on the San Antonio Terrace and may have been involved in activities centered on other areas.

Patterns of chert use are generally similar for both periods. Very black chert from coastal Middle Monterey outcrops overwhelmingly dominates collections from all sites, as is predicted by the Exploitation Potential index (see Chapter 8). The EP index also generally accounts for the rank order of other chert sources used. However, while the recent period data show a clear dichotomy between terrace edge sites with a wide variety of chert sources present and intermediate dune sites with fewer sources represented, early sites show a relatively large number of sources even in small collections. The recent period dichotomy again emphasizes the base camp/special-use camp relationship between terrace edge and intermediate dune sites, while its absence in the early period again emphasizes the simpler pattern seen previously.

The absence of use-wear traces on flake platforms indicates that more than 99 percent of the unused flakes recovered in the study area were produced during tool manufacture rather than resharpening. Technological information indicates that bifaces were virtually the only chipped stone artifacts manufactured in the study area. No sites from either period show evidence for the earliest stages of manufacture; these apparently occurred elsewhere. In addition, early period debitage was probable produced during later stages of manufacture than was recent debitage. No distinct procedure for manufacturing flake tools was identified. Flakes used as tools seem to have been selected mainly from those produced in the earliest stages of biface manufacture, and so must have been brought to the study area along with the partially reduced bifaces.

Two additional aspects of the study collection emphasize the differences between the two periods. Tables 9-40 and 9-41 show, respectively, the frequencies of broken and unbroken tools and of retouched and unretouched tools by period. All frequencies in both tables depart substantially from random expectation (Table 9-40; chi-square=6.2, df=1, .025 p .01, Yules Q=-.67; Table 9-41: chi-square=6.8, df=1, .01 p .005, Yules Q=-.63): early sites contain disproportionately large numbers of 1) broken and 2) retouched tools.

All of this information can be integrated by defining and then comparing the organization in the study area of the activities and of the technology used for those activities. In general terms, the classification as field camps of all sites on the San Antonio Terrace implies that the overall subsistence/settlement system was logistically organized; that is, that the prehistoric inhabitants of the region during both early and late occupations were "collectors" rather than "foragers." The systematic differences between the two periods, however, suggest an increase in the degree of organization in the system through time. The recent sites show this increase particularly in their greater spatial segregation of non-procurement and processing activities.

The sharp dichotomy between terrace edge and central dune sites during this period suggests the establishment of a base camp for extended occupation near the edge of the dunes, from which small hunting parties traveled out, sometimes staying out in the dunes long enough to create archaeologically

Table 9-40. Frequency of Broken and Unbroken Tools by Period.

	Broken	Unbroken	Totals
Recent	22	21	43
Early	16	3	19
	38	24	62

Table 9-41. Frequency of Retouched and Unretouched Tools by Period.

	Broken	Unbroken	Totals
Recent	12	31	43
Early	12	7	19
	24	38	62

recognizable sites. These trips were long enough that shellfish were carried along for provisions (see Analysis of Shell Fish Remains), probably as insurance if no game were sighted. Virtually all tool maintenance and manufacture was carried out in the base camps.

The early system does not show this clear cut difference, although there is a possible tendency for non-processing tools to be found near the terrace edge. The early sites appear to represent much shorter-term hunting trips, where most activities were carried out at a single site. This lack of a "staging area" comparable to the recent terrace edge sites indicates a less centralized organization during earlier times.

Along with this change in activity organization, the basic technological pattern was changing. Binford (1972) discusses a continuum in technological organization from "curated" to "expedient". In extremely simplified terms, curated technologies are characterized by extensive tool maintenance and reuse, and the use of artifacts in many locations other than that where they were manufactured before they were discarded. Discard of curated tools generally occurs only when they are no longer functional, and in the case of hafted tools may take place in central camps far from any use-locations (see Keeley 1982). Populations relying on expedient technologies manufacture, use, and discard their tools at a single location. The reuse of tools is rare, and discard occurs when a task is completed rather than when a tool is worn out.

These extremes can be translated specifically into patterns expected in collections of chipped stone artifacts (see Binford 1977). Expedient technologies should be characterized by high frequencies of flake tools, discard of worn but still useable tools in association with their manufacturing debris, and minimal resharpening or other retouch. Curated technologies should show little relationship between discarded tools and primary manufacturing debris, few flake tools, high frequencies of retouch, and rare discard of still-useful tools.

By these criteria, the study collection appears to represent curated technology overall, but with decreasing emphasis on curation through time. The high rates of retouched and broken tools in the early sites clearly conform to the curated pattern, as does the fairly high frequency of recent tool retouch and the importation of flake tools from outside the study area, which it particularly important during the recent period. The decrease in tool retouch and increase in discarded whole tools in the recent period suggests an increasingly expedient technology. Parenthetically, the flake tools demonstrate the difficulty in trying to apply a simple curated/expedient tool dichotomy in practice: they are "curated" in apparently being transported from their locus of manufacture, but they were "expedient" in their frequent discard in still-useable condition at their locus of use.

This is precisely the opposite of Binford's (1977:35) predictions about the relationship between the degree of subsistence/settlement organization and the degree of technological organization. He argues that increases in the degree of organization such as that documented here for subsistence practices represent increases in efficiency, which should also be apparent in related aspects of behavior; curation for him is efficient technological behavior and so should be related to collecting.

Hunters on the San Antonio Terrace had to balance two major factors: the technological requirements of hunting, and mobility in the dunes. For short trips whose goal is a small number of kills, a strategy of carrying minimal equipment into a single camp, hunting, and then leaving the study area would be suitable. The early pattern of minimal variability in site contents and highly curated technology can be explained by this kind of behavior.

This strategy would not be suitable, however, if the goal of the hunting trip was the systematic collection of large volumes of meat or if increased predation had reduced the animal population and made hunting more difficult. Longer stays in the study area for any reason would increase the diversity of non-hunting, group-maintenance tasks to be performed, and making more kills would require a greater volume of hunting gear. Larger volumes of meat would also be difficult to transport out of the interior of the intermediate dunes. Establishing a temporary base camp where meat and hides could be collected for transport to a residential base and where extra chert could be kept for new tools would be a better strategy in this situation. This may be the strategy which produced the pattern seen in the recent period data.

The notion of increases in technological "efficiency" which Binford correlates with increases in tool curation is clearly problematic in this context. The key to unravelling it is in procurement time. In Binford's examples (particularly Binford 1977), raw materials for tool manufacture cannot be obtained locally and procurement time and expense are therefore high; efficiency in his terms is efficient use of a scarce resource. Maintaining and recycling tools is highly adaptive because they cannot be replaced at will.

This is not the case on the San Antonio Terrace. Extremely high quality chert is readily available at coastal Monterey formation outcrops within six miles of any point in the study area, and the major villages from which the hunters on the terrace presumably came tend to be directly associated with chert outcrops. When essentially unlimited raw material is available, it is <u>not</u> more efficient to invest energy in maintaining most chipped stone tools--it is easier just to pick up another flake. Having solved the problem of having immediate access to tool material and still being mobile enough to hunt by establishing staging areas near the edge of the terrace, a high degree of curation is no longer efficient: in that situation, the cost of maintaining and recycling tools exceeds that of replacing them, because access to raw material is not a limiting factor. Continued frequent reliance on bifacial tools, indicated by the frequency of debitage and preforms, however, suggests that some curation was still important, probably to reduce the equipment it was necessary to carry through the dunes themselves.

Curation is probably more accurately viewed as a response to raw material shortages than to the complexity of the subsistence/settlement system. The shortages may be caused over large areas by the regional absence of tool materials or locally by the nature of a specific activity, such as the proposed early hunting strategy. One implication of this hypothesis is that curation should be rare at the village sites near the San Antonio Terrace that are located adjacent to chert outcrops. Partial reduction of biface blanks outside the study area eliminates waste chert from the material which must be transported and also allows the knapper to recognize and reject obviously flawed pieces. Bringing in completed Stage 2 bifaces during the recent period allows hunters more flexibility in the tools they can manufacture and provides cores from which additional flake tools can be struck if necessary (see Keeley 1980:161). However, this flexibility comes at the expense of mobility and with an increased chance of production failure due to unrecognized flaws in the stone. This chance is less when more completely reduced bifaces are carried, which probably explains the difference in production stages represented by debitage in pre- and post-A.D. 500 sites.

If the shift in hunting strategies proposed here did occur, it may imply that the role in the diet of large game, probably deer, changed from the early to the recent period. Alternatively, the diet may have remained the same, but social changes and/or over-hunting may have caused a reorganization of large-game procurement. Clearly, the data needed to explain the changes seen here must come from other parts of the prehistoric natural and cultural systems around the San Antonio Terrace.

Despite the limitations of the data base discussed in the various sections of this report, the variety of lines of evidence which indicate similar patterns suggest that the general interpretations offered here are reasonable. While they are all in need of further refinement and independent test, these interpretations basically fit the previously hypothesized trend towards increased complexity of subsistence/settlement organization on the central coast over time. The absence of sites older than A.D. 1 precludes the study of full development of this organization, however.

Finally, this analysis has shown that detailed analysis of chipped stone collections can yield important behavioral information. Even if the interpretations presented here ultimately prove to be incorrect, they may at least provide a basis for more sophisticated studies of chipped stone artifacts which address other problems on the central coast and in other areas.

Future work on the terrace could easily test these hypotheses. The major problems with the data available now are the lack of clear chronological control and, accepting the general chronology applied here, the small number of early sites with adequate samples. A particular emphasis on dating, probably by absolute methods, and on sites which can be demonstrated to be early would remedy these deficiencies. Furthermore, the division of the terrace into two segments containing different types of sites also provides the basis for a stratified sampling program. Last, the northern and coastal portions of the terrace are barely represented in the sample analyzed, and there are suggestions of systematic differences between them and the areas which have been investigated. Any work in these regions would provide important comparative information.

ANALYSIS OF SHELLFISH REMAINS

Purpose and Methods of Analysis

Purpose: The purpose of this section of the report is the analysis of marine shellfish remains recovered in archaeological investigations conducted to mitigate impacts of MX Missile development at Vandenberg Air Force Base. Shell assemblages from 20 archaeological sites are described. These sites are: SBa-706, -980, -998, -1036, -1038, -1070, -1070E, -1153, -1154, -1173, -1174, -1177, -1179, -1181, -1193, -1709-H, -1718, -540, -1683, and -1753. Two additional assemblages--one from an area not assigned an archaeological site trinomial designation (Locus A) and one lacking provenience data (Unprovenienced VTN Collections)--are also described.

Shellfish remains in each assemblage are identified and their amounts determined. These basic data are then used to address three questions of immediate relevance to the research design:

1. What kinds of activities are represented by the shellfish remains?
2. At what time of year did these activities take place?
3. What role did these activities play in the structure and maintenance of regional settlement patterns?

The third question is focused particularly on the intensity and diversity of shellfish exploitation at sites in different locations occupied during different chronological periods.

Information on the physical condition of shellfish remains is used to assess the extent to which sites have been affected by wind erosion. Criteria for determining the extent and causes of shell deterioration are discussed.

Methods of Analysis

Sorting and Classification: The shellfish remains in each assemblage were identified by visual examination, and, when necessary, with the aid of a 10x hand lens. They were then sorted by species or by the most exclusive taxon possible when specific identification was not practicable. The shell in each category was weighed and the data were recorded on shellfish analysis forms. Table 9-42 lists the shellfish categories utilized in the analysis.

An explanatory note on the selection of some of the categories is in order. *Tegula* sp. encompasses at least three species exploited for food by aboriginal collectors in the area: *T. funebralis*, *T. brunnea*, and *T. gallina*. These different species are readily distinguishable in the intertidal zone, but identification is occasionally more difficult among the small, weathered fragments in local shell middens. The *Tegula* were therefore lumped together, with the understanding that *T. funebralis* is by far the most abundantly represented.

No effort was made to distinguish between the small chitons in the collection; they were simply combined within the general class category Polyplacophora. This was done largely because it is difficult to identify the weathered valve fragments usually found in the collections.

Nomenclature for the Mollusca generally follows McLean (1978) although Morris (1966) served as a supplementary source. Nomenclature for the Cirripedia follows Pilsbry (1916) and for all other forms Ricketts and Calvin (1968) is the authority. McLean (1978), Morris (1966), and a number of damp and hirsute local shellfish collectors were consulted before compiling the list of common shellfish names in Table 9-42.

Proper scientific names for species include the generic and specific titles as well as the date and author of the creature's original description. While clearly appropriate in some circles, this system is unwieldy and difficult for most nonspecialists. In addition, it is clear that the essential stability attained in local shellfish nomenclature allows certain liberties to be taken in the matter of formal names without serious risk of ambiguity. Shellfish names are therefore presented much as archaeologists use and abuse them in conversation, with sincere apologies to those whose scientific sensibilities are thereby violated.

Meat Weight Estimates: The amount of meat represented by analyzed shellfish remains has been calculated when possible for each shellfish category in each assemblage. The calculations are based on specific meat weight to shell weight ratios determined from fresh specimens (Table 9-43). The fresh specimens of all but two species were taken from the Purisima Point and Lions

Table 9-42. Shellfish Scientific and Common Names.

Scientific Name	Common Name
Mollusca	mollusks
Haliotis cracherodii	black abalone
Haliotis rufescens	red abalone
Haliotis sp.	abalones
Acmaea mitra	white-cap limpet
Collisella pelta	shield limpet
Collisella digitalis	fingered limpet
Collisella strigatella	---
Collisella asmi	---
Notoacmea scutum	plate limpet
Lottia gigantea	owl limpet
Acmaeidae, undifferentiated	limpets
Tegula sp.	top shells
Astraea undosa	wavy turban
Crepidula adunca	hooked slipper shell
Crepidula sp.	slipper shells
Nucella emarginata	emarginate dogwinkle
Nucella canaliculata	channeled dogwinkle
Nucella sp.	dogwinkles
Olivella biplicata	purple olive
Gastropoda, undifferentiated	univalves
Cryptochiton stelleri	giant chiton
Polyplacophora, undifferentiated	chitons
Mytilus californianus	California mussel
Septifer bifurcatus	platform mussel
Hinnites multirugosus	purple-hinged scallop
Tivela stultorum	Pismo clam
Platyodon cancellatus	---
Protothaca staminea	common littleneck
Penitella penita	flap-tipped piddock
Pholadidae, undifferentiated	piddocks
Pelecypoda, undifferentiated	bivalves
Mollusca, undifferentiated	mollusks
Arthropoda	arthropods
Balanus cariosus	---
Balanus glandula	---
Balanus tintinnabulum	---
Tetraclita squamosa	---
Pollicipes polymerus	gooseneck barnacle
Cirripeda, undifferentiated	barnacles
Decapoda, undifferentiated	crabs
Echinoderma	echinoderms
Strongylocentrotus sp.	sea urchins

Table 9-43. Shellfish Meat Weight/Shell Weight Quotients

Scientific Name	Meat Weight/ Shell Weight	Sample Size
Mollusca		
Haliotis cracherodii	0.71	4
Haliotis rufescens	unknown	--
Haliotis sp.	n.d.	--
Acmaea mitra	0.56	6
Collisella pelta	0.80	7
Collisella digitalis	0.71	13
Collisella strigatella	0.89	4
Collisella asmi	0.74	13
Notoacmea scutum	0.75	5
Lottia gigantea	0.73	18
Acmaeidae, undifferentiated	n.d.	--
Tegula sp.	0.46	54
Astraea undosa	unknown	--
Crepidula adunca	0.59	7
Crepidula sp.	0.59	--
Nucella emarginata	0.88	12
Nucella canaliculata	0.75	3
Nucella sp.	n.d.	--
Olivella biplicata	unknown	--
Gastropoda, undifferentiated	n.d.	--
Cryptochiton stelleri	0.30	2
Polyplacophora, undifferentiated	n.d.	--
Mytilus californianus	0.36	141
Septifer bifurcatus	0.55	40
Hinnites multirugosus	unknown	--
Tivela stultorum	0.22	9
Platyodon cancellatus	unknown	--
Protothaca staminea	0.61	12
Penitella penita	unknown	--
Pholadidae, undifferentiated	n.d.	--
Pelecypoda, undifferentiated	n.d.	--
Mollusca, undifferentiated	n.d.	--
Arthropoda		
Balanus cariosus	unknown	--
Balanus glandula	unknown	--
Balanus tintinnabulum	unknown	--
Tetraclita squamosa	unknown	--
Pollicipes polymerus	unknown	--
Cirripeda, undifferentiated	n.d.	--
Decapoda, undifferentiated	n.d.	--
Echinoderma		
Strongylocentrotus sp.	unknown	--

n.d. = not determinable
* = number of fresh specimens dissected and weighed

Head areas in February 1982. The only exceptions are Tivela stultorum, the fresh specimens of which were taken at Goleta Beach, Santa Barbara County, in January 1982, and Cryptochiton stelleri collected at Purisima Point in April 1980.

The procedure for determining the meat to shell ratios of fresh specimens follows. First, the specimens are dissected to remove completely the soft tissue parts from the shell. The soft parts are then placed briefly between sheets of absorbent paper to draw off excess water.

Finally, the soft tissue is weighed to the nearest 0.1 g. The empty shells are wiped dry and weighed and the results recorded. The meat weight/shell weight values presented in Table 9-43 derive from the averaged meat to shell ratios of each of the fresh specimens measured in each shellfish category. These values are multiplied by the weights of archaeological shellfish remains to determine the amount of meat represented by the archaeological shell.

This method is straightforward, but its utility is limited by a number of problems. Fresh specimens were not available for some shellfish categories (these are listed as "unknown" in Table 9-43); only a few specimens were available for others. Meat weight/shell weight values are not determinable for shellfish categories that include more than one species, such as the undifferentiated chitons and limpets. An exception to this rule was made in the case of Tegula sp., which has been assigned the meat weight/shell weight value of the major species in the category: T. funebralis.

Another problem is that the sample of fresh specimens may not provide a meat weight/shell weight value applicable to all archaeological assemblages. The ratio of meat to shell in some species varies regularly with animal size. For example, in Mytilus californianus small animals generally yield less meat per unit of shell weight than large animals. Meat weight/shell weight values range from about 0.30 for Mytilus less than 4.0 cm long to 0.52 for Mytilus over 14 cm long; the 0.36 value used in this report is derived from a sample of fresh specimens guessed to be in the same size range as the small animals typical of most of the assemblages. However, meat weights for large mussels such as those found at SBa-1174 will tend to be underestimated when the 0.36 value is used. In some cases, variability in meat weight/shell weight ratios related to animal size could not be determined because the size of fresh specimens was constrained by legal size limits.

The loss of shell weight from decomposition is the largest source of error in the estimating of meat weights. Some shell fragments are too small to be retained in the screens used in the field and during analysis. The loss in screening for the assemblages under consideration is estimated to range roughly between 20 percent in slightly weathered assemblages to 40 percent in heavily weathered assemblages. Loss of shell weight from leaching and dehydration may account for an additional 10 percent or higher weight loss. Thus, estimated meat weights for the archaeological assemblages under consideration are consistently lower than the real meat weight values.

No attempt has been made to correct the meat weight/shell weight values for variation resulting from differences in animal size, preservation, etc. Insufficient data are available on the effects of different variables to allow construction of accurate assemblage-specific correction factors. The suggestions made above regarding variability in size and preservation can, if desired, be used as a rough guide to correcting meat weight/shell weight values, but the estimated meat weight of shell categories in the assemblages under consideration are perhaps most prudently regarded as relative rather than absolute values.

Minimum Number of Individuals: The minimum number of individuals (MNI) represented in each lot and assemblage was determined by counting particular shell parts for each shellfish category represented. The criteria are summarized in Table 9-44. The parts selected for counting were chosen for easy identifiablility, good relative preservability, and an invariable numerical relationship to the individual animal.

The reliability of the MNI counts is generally very good in well-preserved assemblages. However, the method is fairly effective even in badly weathered assemblages because the counted elements, such as pelecypod beaks and gastropod collumellae, are very resistant to decomposition. The strength of the method lies in its simplicity and robustness; I am confident that the MNI counts in most cases reflect very closely the actual number of individuals of each category present in the excavated assemblages.

In cases in which multiple parts were counted for a single individual (e.g., two beaks for each Mytilus californianus), odd parts not sufficient to form a complete individual were counted together as one individual when the lots were combined in the assemblage description tables (see Assemblage Descriptions below). Thus, a total of 21 Mytilus valves in an assemblage would be taken to represent 11 individuals. Similarly, all noncountable parts in a given category (such as Mytilus valve edges) were taken to represent one individual when no countable parts were available. For example, in Table 9-57 one individual was counted for each of four categories, although no countable parts as defined in Table 9-44 are present in the assemblage.

The initial expectation that MNI might be, by itself, an effective and very fast measure of the shellfish in an assemblage has not been sustained. Intersite variability in mean animal size was much greater than expected, so that MNI is a poor measure of the food value, expressed as meat weight, represented by the remains.

Extent of Weathering: The deterioration of archaeological shellfish remains depends upon a wide range of factors, including soil acidity, vegetation, drainage, bioturbation, and many others. Some of these variables are, with respect to shell decomposition, more or less constant at the sites under consideration in this report. The major variables determining the differential deterioration of shellfish remains in similar deposits are 1) "traumatic" weathering by wind deflation or redeposition, and 2) the length of exposure time to "chronic" weathering agents such as soil acids. This second variable is, of course, related to the age of the archaeological deposits. However,

Table 9-44. Determination of Minimum Number of Individuals.

Scientific Name	MNI Criterion
Mollusca	
Haliotis cracherodii	no. of spires
Haliotis rufescens	no. of spires
Haliotis sp.	no. of spires
Acmaea mitra	no. of apexes
Collisella pelta	no. of apexes
Collisella digitalis	no. of apexes
Collisella strigatella	no. of apexes
Collisella asmi	no. of apexes
Notoacmea scutum	no. of apexes
Lottia gigantea	no. of apexes
Acmaeidae, undifferentiated	no. of apexes
Tegula sp.	no. of collumellae
Astraea undosa	no. of collumellae
Crepidula adunca	no. of apexes
Crepidula sp.	no. of apexes
Nucella emarginata	no. of collumellae
Nucella canaliculata	no. of collumellae
Nucella sp.	no. of collumellae
Olivella biplicata	no. of spires
Gastropoda, undifferentiated	no. of collumellae
Cryptochiton stelleri	no. of posterior valves
Polyplacophora, undifferentiated	no. of posterior valves
Mytilus californianus	1/2 no. of beaks
Septifer bifurcatus	1/2 no. of beaks
Hinnites multirugosus	1/2 no. of beaks
Tivela stultorum	1/2 no. of beaks
Platyodon cancellatus	1/2 no. of beaks
Protothaca staminea	1/2 no. of beaks
Penitella penita	1/2 no. of beaks
Pholadidae, undifferentiated	1/2 no. of beaks
Pelecypoda, undifferentiated	1/2 no. of beaks
Mollusca, undifferentiated	not determinable
Arthropoda	
Balanus cariosus	1/6 no. of compartments
Balanus glandula	1/6 no. of compartments
Balanus tintinnabulum	1/6 no. of compartments
Tetraclita squamosa	1/4 no. of compartments
Pollicipes polymerus	1/48 no. of plates
Cirripeda, undifferentiated	1/6 no. of compartments
Decapoda, undifferentiated	1/2 no. of claws
Echinoderma	
Strongylocentrotus sp.	1/10 no. mouth parts

age cannot be determined simply from the condition of shellfish remains because the effects of weathering agents appear at different rates in different kinds of deposits. For example, a dense midden accumulation may create a chemical environment in which shells are preserved in relatively good condition for thousands of years; a sparse accumulation of shellfish remains under precisely the same soil and weather conditions might be destroyed completely in a short time. Ideally, knowledge of the complex variables of soil, climate, and the character of the original deposit should allow the ranking of sites by age based on the extent of weathering. In fact, although the relationships among these variables are sometimes unusually clear, data necessary to establish the quantitative effects of different variables under different conditions are not available. Nevertheless, the extent of weathering in a shellfish assemblage is an indicator of the kinds of damage, such as wind-weathering, to which a deposit has been subjected.

Observations on the condition of shellfish remains were made by lot number for each of the analyzed assemblages. The traumatic damage of wind deflation or redeposition was determined by the presence of characteristic wear patterns on surviving shells. These patterns, collectively referred to as wind polish, can be summarized as follows:

1. Nacreous calcium carbonate layers of shellfish such as Mytilus, Tegula and Haliotis have "frosted" appearance;
2. Broken edges are rounded and polished;
3. Dull polish is present on Cryptochiton valves; and
4. Hardshell clams and, in extreme cases, Cryptochiton show smooth, "chalky" surfaces.

The substantial presence of at least two of these patterns in a lot was interpreted as evidence of wind deflation or redeposition.

It is noteworthy that the surface environment in the San Antonio Terrace region is extremely deleterious to the preservation of shellfish remains. Once exposed to the persistent onshore winds, archaeological shellfish remains are immediately subject to traumatic mechanical damage both by being transported across the ground surface and by impacts with other wind-transported particles. Observations of sites at Purisima Point suggest that whole shells eroding from the midden are quickly reduced to tiny particles; after a few hundred meters of wind-transport these are thoroughly incorporated into the local dune sand. Shells recovered with wind polish are therefore not abundant on the Terrace, and generally represent either shells newly exposed on the surface, or shells that were briefly exposed before reburial in the shifting sand.

The effects of chronic weathering are manifested as progressive deterioration founded on the relationship between chemical dissolution and mechanical damage. Typically, acids in soil or rainwater weaken the shell, increasing its susceptibility to mechanical damage by rodents or soil movement, which in turn exposes a greater amount of shell surface-area to chemical attack.

Three stages in this pattern of decomposition are defined for the assemblages under consideration. These stages are recognized by the following attributes:

1. Slight weathering: *Mytilus* periostracum destroyed; *Mytilus*, *Tegula*, and *Haliotis* nacre bright and hard; barnacle compartments often articulated; *Mytilus* beaks not exfoliated; *Mytilus* and *Tegula* shells fairly resistant to breakage in the hand.

2. Moderate weathering: nacre slightly dull and flaky; a few barnacle compartments articulated; *Mytilus* beaks often partly exfoliated; shells easily broken in the hand.

3. Heavy or extreme weathering: nacre dull, flaky or missing entirely; barnacle compartments rarely articulated; *Mytilus* beaks badly exfoliated; shells crumble in the hand with only slight pressure.

Exploitation of Local Shellfish Resources

Distribution of Local Shellfish Beds: Extensive and diverse shellfish beds are located continuously along the coast in the vicinity of the San Antonio Terrace. These beds are easily accessible from the Terrace, and provided the aboriginal inhabitants with a relatively stable, predictable resource available throughout the year.

Three major areas of shellfish beds, distinguished by location and habitat type, are found within easy walking distance of any point on the San Antonio Terrace. These areas are: 1) the Purisima Point area, comprising the rocky outer coast from around the mouth of Canada Tortuga to about 2 km north of Purisima Point; 2) the San Antonio area, including the sandy beach from about 2 km north of Purisima Point to approximately 1.5 km south of Lions Head; and 3) the Lions Head area, encompassing the rocky coast from about 1.5 km south of Lions Head north to Point Sal.

The Purisima Point area comprises about 9 km of open coastline. The area is characterized by intertidal bedrock outcrops supporting extensive mussel beds. At low tide these beds are typically exposed to a distance of about 50 to 100 m from the shore, although in places exposure is much greater. A -0.6 low tide at Purisima Point in February 1982 exposed an area extending some 400 m from shore.

The San Antonio area encompasses about 9 km of wide, sandy beach flanked by rocky promontories to the north and south. Surf clams such as *Tivela stultorum* are the major invertebrate prey species available in this area. The shellfish resources of the San Antonio area are poor compared to those of the Purisima Point and Lions Head areas, both with respect to resource density and the accessibility of the resource to the human predator.

Small estuaries capable of supporting exploitable shellfish communities may once have existed in the San Antonio Terrace area at the mouths of San Antonio Creek and Shuman Canyon. Both stream mouths are currently closed

by sand dunes, but San Antonio Creek has periodically been open to the sea in historic times. Small estuaries could conceivably have supported a variety of shellfish typical of protected waters, such as Macoma nasuta and Chione sp., but no evidence of such exploitation has been observed at archaeological sites in the vicinity of the occluded stream mouths.

The Lions Head area includes about 8 km of intertidal bedrock outcrops interspersed occasionally with stretches of sandy beach. The rocky foreshore in this area supports large mussel beds; however, these beds are significantly smaller than those in the Purisima Point area. The small beaches probably support exploitable surf clam populations.

Locally available shellfish are listed with their typical habitats in Table 9-45.

Composition of Shellfish Communities: The Purisima Point and Lions Head areas are characterized by intertidal rocks supporting large mussel communities. The major prey species in these communities is Mytilus californianus, a fast-growing, rock-perching bivalve typical of surf-swept rocky foreshores along nearly the entire Pacific coast of North America. Mytilus occurs from the upper intertidal zone to sublittoral waters, but its range is limited by predators--particularly sea stars--in deep water and by the periodic desiccation of the high upper intertidal zone. However, Mytilus is found in greatest numbers and density in the middle intertidal zone, where the mussels often obscure completely the upper surfaces of exposed rocks. Mytilus grows most quickly in lower intertidal and sublittoral waters, but sea star predation in these zones severely limits the density of the beds.

A diverse assemblage of rock-perching invertebrates is typically found with Mytilus in local mussel beds. Barnacles in this assemblage include Pollicipes polymerus, Tetraclita squamosa, Balanus cariosus, Balanus tintinnabulum, Balanus glandula, Chthamalus fissus, and Chthamalus dalli. The latter three species are usually found among upper intertidal mussels and on rocks higher in the intertidal then Mytilus occurs; B. cariosus is typical of lower intertidal beds. The barnacles are edible, but the enormous effort required to extract a minute quantity of flesh from these animals probably precludes their having been deliberately collected by the aborigines. A possible exception is Pollicipes polymerus; the fleshy "necks" of large individuals may yield sufficient meat to justify collection and processing, perhaps during periods of dietary stress.

The platform mussel Septifer bifurcatus is commonly found in close association with Mytilus. Septifer is edible but small, seldom exceeding 4 cm in length. This species generally occurs archaeologically in smaller amounts relative to Mytilus than would be expected if the two species were randomly selected in the mussel beds. This suggests that the platform mussel's small size and strong byssal threads discouraged exploitation.

A wide variety of chitons occurs near and among the local mussel beds. The largest of these is Cryptochiton stelleri, usually found nestled in rock niches and beneath overhangs in the lower intertidal zone and upper subtidal. Cryptochiton congregates during spring breeding and is most easily collected at that time. Clusters of Cryptochiton valves observed by this writer at

Table 9-45. Shellfish Typical Habitats.

Scientific Name	Typical Habitat
Mollusca	
Haliotis cracherodii	m/Ro
Haliotis rufescens	ls/Ro
Haliotis sp.	mls/Ro
Acmaea mitra	mls/Ro
Collisella pelta	mls/Ro
Collisella digitalis	u/Ro
Collisella strigatella	m/Ro
Collisella asmi	u/Ro(x)
Notoacmea scutum	m/Ro
Lottia gigantea	u/Ro
Acmaeidae, undifferentiated	umls/Ro
Tegula sp.	um/Ro
Astraea undosa	ls/Ro
Crepidula adunca	uml/Ro(x)
Crepidula sp.	umls/RoRo(x)MoMp
Nucella emarginata	ml/Ro
Nucella canaliculata	ml/Ro
Nucella sp.	ml/Ro
Olivella biplicata	ls/Mo
Gastropoda, undifferentiated	all habitats
Cryptochiton stelleri	ls/Ro
Polyplacophora, undifferentiated	mls/Ro
Mytilus californianus	uml/Ro
Septifer bifurcatus	ml/Ro
Hinnites multirugosus	ls/Ro
Tivela stultorum	ls/Bo
Platyodon cancellatus	l/Bo
Protothaca staminea	ml/BoBp
Penitella penita	ls/Bo
Pholadidae, undifferentiated	ls/Bo
Pelecypoda, undifferentiated	all habitats
Mollusca, undifferentiated	all habitats
Arthropoda	
Balanus cariosus	ls/RoRo(x)
Balanus glandula	u/RoRo(x)
Balanus tintinnabulum	ml/RoRo(x)
Tetraclita squamosa	ml/RoRo(x)
Pollicipes polymerus	uml/RoRo(x)
Cirripeda, undifferentiated	umls/RoRo(x)
Decapoda, undifferentiated	mls/MoMp
Echinoderma	
Strongylocentrotus sp.	ls/Mo

Key to Symbols

u	upper intertidal	Ro	Rock-perching, open coast
m	middle intertidal	Ro(x)	rock-perching, (on mollusk shells), open coast
l	lower intertidal	Bo	burrowing, open coast
s	subtidal	Bp	burrowing, protected waters
		Mo	on bottom, open coast
		Mp	on bottom, protected waters

coastal middens such at SBa-225 at Purisima Point suggest that prehistoric collectors sometimes focused on this species, modern skepticism regarding its esculence notwithstanding (see Ricketts and Calvin 1968:91).

Other, smaller chitons available from the Purisima Point and Lions Head rocks occur primarily from the middle intertidal to sublittoral zones, some in close association with Mytilus. At least ten different species are represented locally, but no effort has been made to separate these different types in the archaeological assemblages.

Two small predatory gastropods, Nucella emarginata and Nucella canaliculata, commonly occur in local mussel beds, where they feed largely upon barnacles and small Mytilus. Mussel collecting almost inevitably results in the unintentional taking of a few Nucella, which may account for their regular occurence in Vandenberg archaeological assemblages. Both species are edible, however, and accidental collecting does not prelude the consuming of the animals by the collectors.

Numerous limpet species are found in local rocky intertidal areas. Lottia gigantea is the largest of these and among the most accessible, often occurring in the upper intertidal zone above the level of typical Mytilus habitat. Many smaller limpets, including Collisella pelta, Collisella digitalis, Collisella strigatella, Notoacmea scutum and others, are common in the upper and/or middle intertidal zones both in close association with Mytilus and on vertical or overhanging rock surfaces where Mytilus are not densely distributed. The heavy-shelled Acmaea mitra generally occurs in deeper water. The diminutive Collisella asmi often occurs on upper intertidal rocks, but is more typically found perched on the shells of mollusks such as Mytilus and Tegula funebralis. Too small to be a likely target of human predation, C. asmi is probably introduced into archaeological assemblages attached to the shells of its more desirable hosts.

Unintentional transport is also the probable source-to-site vector of slipper shells of the genus Crepidula. The most common of these in the Purisima Point and Lions Head areas is C. adunca, a small species typically found on Mytilus, Haliotis, and Tegula shells.

Several top shells of the genus Tegula are found in the Purisima Point and Lions Head areas, but only the black top shell T. funebralis is very common. This small snail is largely restricted to the middle intertidal and the lower portion of the upper intertidal. It is found among Mytilus and also occurs very abundantly in small niches and crevices that provide a measure of protection from the pounding surf. In such places T. funebralis can be collected quickly and in large numbers. Perhaps as a result T. funebralis constitutes a large proportion of the shell detritus at many prehistoric middens in the area.

The black abalone Haliotis cracherodii occurs in small numbers in the Purisima Point and Lions Head areas, where it is usually found in the lower intertidal zone but only rarely is encountered in its preferred upper to middle intertidal habitat. Modern overcollecting in the higher, more accessible portions of the black abalone's range has undoubtedly created this unnatural

distribution. The highly visible, slow-growing black abalone is extremely sensitive to overexploitation, and excessive collecting pressure on this shellfish is quickly reflected in its spatial distribution and population structure. The effect of prehistoric exploitation on the intertidal distribution of black abalones was probably much like that of modern collecting. It could be argued that H. cracherodii is a common, upper to middle intertidal species in protected environments, but is typically an uncommon, lower intertidal species in the presence of human predators.

Haliotis rufescens, the red abalone, occurs in the Point Purisima and Lions Head areas but has not been observed by this writer in the intertidal zone. Empty shells of these animals are fairly common on local beaches, indicating the existence of a substantial population probably in the upper sublittoral and perhaps the extreme lower intertidal. The small amounts of H. rufescens found in aboriginal sites in the area may represent shellfish collected for food or empty shells gathered from the beach for use in making tools and ornaments.

There are a few places at Purisima Point and south of Lions Head where the shale bedrock, striking at a steep angle, has formed in the middle intertidal zone a series of low, parallel ridges aligned roughly east to west. The narrow interstices are partially filled with boulders, coarse gravel, and sand, and the ridges provide wave protection. In these unique microhabitats thrive large populations of the common littleneck Protothaca staminea. These clams also occur in protected coarse gravels at Purisima Point; in both habitat types they are an important focus of modern shellfish collecting. Protothaca was taken regularly, if not in great numbers, by the aborigines in the area.

The long, sandy beach of the San Antonio Terrace area supports a very narrow range of intertidal shellfish, only one of which--the Pismo clam Tivela stultorum--is suitable for human predation. Tivela is usually found buried a short distance into the sandy substrate at low tide and in the upper sublittoral. Modern shellfish collectors claim that Pismo clams are not particularly common in the San Antonio Terrace area, and almost invariably recommend the beaches to the north. One informant claimed that the poor local clamming is due to rapid shifting of the sandy bottom.

Season of Shellfish Exploitation: There are two kinds of indicators of the season of shellfish exploitation available from archaeological remains. These are direct and indirect indicators. Direct indicators are those based on analysis of shell structure or composition to determine the season during which the death of the archaeological shellfish occurred. They stem from observations that the chemical composition and physical structure of certain mollusk shells are subject to regular variation during the year. Indirect indicators are those based on the presence or absence in archaeological assemblages of certain species differentially available to aboriginal collectors during the year.

The most widely utilized direct indicator of seasonality of shellfish exploitation is the pattern of growth rings in bivalve shells. The technique of measuring growth rings to determine season of exploitation, pioneered by

Coutts (1970) and others, has been used with some success in California. Outstanding studies include Weide's (1969) analysis of Tivela stultorum shells from Ora-82 and Drover's (1974) study of Chione valves.

Despite the publication of a number of successful growth ring studies, the utility of this kind of analysis is significantly constrained by local environmental conditions. In many cases there exist variables that cannot be controlled without continuous monitoring of oceanographic conditions, impossible in archaeological contexts. For example, Macko (personal communication 1981) suggests that such irregularly occurring events as sand bar formation at the mouth of the Goleta Estuary in Santa Barbara County may have a major effect on growth ring formation in Chione undatella by precipitating rapid and extreme changes in water salinity. A study conducted by the writer with modern Protothaca staminea shells from the Devereaux and Goleta beaches near Santa Barbara revealed no correlation between season of death and structure of growth rings. A small series of Tivela stultorum from the same beaches showed a similar lack of correspondence between growth rings and season of death.

In any event, analysis of growth rings of hardshell clams such as Tivela, Chione, and Protothaca cannot be applied to the collections under consideration. . Although Tivela and Protothaca are represented in several assemblages, the shells are so few and fragmentary that growth ring analysis is not feasible.

The technique based on growth rings to determine season of collection from Mytilus californianus shells is currently under development. This technique is an outgrowth of research conducted by Coe and Fox (1942). They found that the periodic exposure and handling of mussels measured for growth-rate studies was associated with the production of distinct rings in the shells:

> This disturbance caused the withdrawal of the mantle from the edge of the shell and when growth is resumed after reaching the sea the new layers of prismatic shell and periostracum are not directly continuous with the old. Since the new growth in such cases underlies the old, the latter will then be more or less distinctly raised as a growth ring [Coe and Fox 1942:24].

Having observed the relationship between disturbance and ring formation, Coe and Fox went on to identify a number of variables involved in growth ring production in the natural Mytilus habitat. These include gametogenesis, spawning, water temperature, food supply, storms, and exposure to air between tides (1942:23-24). Large series of Mytilus from Goleta Point reveal that growth rings, while occurring throughout the year, cluster during winter months. This is the time during which storms are most frequent and violent, very low tides occur regularly, water temperatures are low, and, as determined by Young (1942), spawning activity is most intensive.

It follows that examination of large series of archaeological Mytilus californianus from short-term depositional contexts should allow a rough estimate of the season of death to be made. Applicability of this method to the collections under consideration is limited by the absence of whole mussel valves from all sites but SBa-1179. In the SBa-1179 collection, however, whole valves are extremely small, representing individuals less than one year old judging by Coe and Fox's (1942) growth rate data. No pattern in growth ring frequency could be established by the writer from these shells, partly because a whole annual cycle is not reflected in the shells, and perhaps also because the highly variable growth rate and the absence of spawning in very young animals prevent regular growth ring development.

A second direct indicator of seasonality is the ratio of 0-18 to 0-16 in calcium carbonate deposited in marine shells. The ratio is directly related to water temperature and thus to season of carbonate deposition; measurement of the ratio in the shell carbonate formed shortly before the death of the animal can be interpreted to determine season of death (Shackleton 1973; Killingley 1981). Unfortunately, the method is extremely expensive and its use with respect to the collections under consideration is of very limited utility due to the paucity of intact shells noted above. No 0-18 analysis was attempted for this report.

Indirect indicators of the season of shellfish collecting are generally less definitive than direct indicators, but at least one is applicable to the collections from the MX-related archaeological research. Cryptochiton stelleri congregates in protected rocky foreshore areas in the spring for breeding, having moved up from deeper water for that purpose (Ricketts and Calvin 1968:92). This seems to be the only time of the year these chitons are available in numbers; this writer has observed the animals at Purisima Point in April, but thorough searches at other times failed to yield even a single individual. Of course, some Cryptochiton can be taken throughout the year, so that the presence of a few valve fragments on a site does not constitute prima facie evidence of spring occupation. However, where Cryptochiton forms a significant proportion of a site's shellfish assemblage a spring occupation is very likely.

The extremely low tides of winter expose portions of the lower intertidal zone not easily accessible to collectors at other times of the year. Winter collecting that takes advantage of very low tides might be expected to yield higher proportions of shellfish typical of the lower intertidal (e.g., Acmaea mitra than summer collecting. Because Mytilus californianus generally grow faster and are less accessible in deep water, winter collecting could result in the taking of larger mussels than summer collecting.

Modern collectors of shellfish in Santa Barbara County generally limit their hunting of filter-feeding mollusks such as Mytilus californianus and Protothaca staminea to the late autumn, winter, and early spring because of the danger of dinoflagellate ("red tide") poisoning. In fact, however, dangerous dinoflagellate concentrations are of infrequent occurrence and brief duration; short-term avoidance based on observation of water conditions is

sufficient to ameliorate fully the danger. Red tide was probably not a significant factor in the seasonality of shellfish exploitation by the prehistoric inhabitants of the region.

Assemblage Descriptions

The following text and tables present the data on shellfish remains for the twenty-two assemblages in the collection. A few changes in site designations made between the time of fieldwork and analysis and the time of this writing are reflected in these data summaries. Site SBa-1718 was formerly recorded as SBa-1179 North. SBa-1753 was until recently referred to only by its field number, WF-I. Locus A has never been assigned a trinomial designation.

Shellfish remains collected and initially analyzed as part of the eastern shelter survey have been assigned to sites SBa-540 and 1683. Shellfish remains from the FOCL survey have been reassigned to sites SBa-706, -980, -1038, and -1709-H. Part of the original SBa-980 assemblage has been reassigned to site SBa-1070. Collections from two sites for which lot numbers were assigned to marine shellfish remains--SBa-1155 and -1173 Vic.--do not actually contain such remains.

All weights and percentages in the tables have been rounded to the nearest one-tenth gram or one-tenth of one percent, respectively. The asterisk (*) is employed to designate values rounding to less than 0.1 g or 0.1 percent. Entries in the Estimated Meat Weight column are labeled not determinable (n.d) when meat weight/shell weight ratios were not available from Table 9-43.

Assemblages are treated as the basic units of analysis. This is due largely to the small sample sizes available. In general, when these samples are broken down by lot the resulting amounts of shellfish remains are so small that analysis of internal site variability is impossible.

All shellfish remains tabulated in the assemblage descriptions are retainable in 1/8 inch mesh screen. Smaller fragments were collected at some sites, but they invariably compose so small a proportion of the total sample, are so difficult to identify, and require such great expenditures of time and effort to sort that their analysis was not considered worthwhile or practicable.

SBa-706: The assemblage of shellfish remains from SBa-706 is the second-largest of the twenty-two assemblages by weight, and contains the largest number of shell categories (Table 9-46). The major species by shell weight and estimated meat weight is *Mytilus californianus*, although *Tegula* sp. seems to have been taken in slightly larger numbers. *Haliotis cracherodii* and *Cryptochiton stelleri* are present in minor amounts; the remaining twenty-five categories are represented by traces only. The assemblage is dominated by rock-perching species to the near-exclusion of other forms.

The mean weight of individual *Mytilus* shells (two valves), as determined by the suspect but sole available method of dividing total shell weight by MNI, is 3.6 g. *Tegula* mean shell weight is 2.2 g.

Table 9-46. Shellfish Remains from SBa-706.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	93.4	7.1	66.3	3
Haliotis sp.	3.1	0.2	n.d.	1
Collisella pelta	0.8	0.1	0.6	3
Collisella digitalis	0.1	*	0.1	2
Collisella strigatella	0.5	*	0.4	3
Collisella asmi	0.3	*	0.2	1
Notoacmea scutum	0.9	0.1	0.7	3
Acmaeidae, undifferentiated	2.0	0.2	n.d.	9
Tegula sp.	414.3	31.3	190.6	185
Crepidula adunca	2.6	0.2	1.5	22
Crepidula sp.	0.1	*	0.1	1
Nucella emarginata	5.1	0.4	4.5	8
Nucella canaliculata	0.5	*	0.4	2
Nucella sp.	0.7	0.1	n.d.	4
Gastropoda, undifferentiated	0.1	*	n.d.	1
Cryptochiton stelleri	64.1	4.8	19.2	4
Polyplacophora, undifferentiated	21.5	1.6	n.d.	13
Mytilus californianus	630.1	47.7	226.8	174
Septifer bifurcatus	3.2	0.2	1.8	6
Protothaca staminea	9.4	0.7	5.7	5
Pelecypoda, undifferentiated	2.4	0.2	n.d.	1
Mollusca, undifferentiated	0.3	*	n.d.	1
Balanus cariosus	18.7	1.4	n.d.	6
Balanus glandula	0.7	0.1	n.d.	2
Balanus tintinnabulum	9.5	0.7	n.d.	8
Tetraclita squamosa	5.0	0.4	n.d.	3
Pollicipes polymerus	10.0	0.8	n.d.	5
Cirripedia, undifferentiated	11.8	0.9	n.d.	8
Decapoda, undifferentiated	2.4	0.2	n.d.	1
Total	1321.7		518.9+	

The shellfish remains are slightly to moderately eroded and display no evidence of wind polish.

A fragment of Mytilus shell fishhook of indeterminate type is the only piece of deliberately modified shell in the assemblage.

SBa-980: SBa-980 yielded 176.0 g of shellfish remains, about 80 percent of which is composed of Tegula sp. and Mytilus californianus in approximately equal amounts Table 9-47). However, more than twice as many Tegula individuals are present than Mytilus. Sixteen shellfish categories are represented. Cryptochiton stelleri forms a substantial portion of the assemblage by shell weight, suggesting a possible spring occupation. Nearly all of the shell in the assemblage is attributable to rock-perching mollusks.

Mytilus individuals are generally fairly large, with a mean shell weight of 4.4 g. Tegula mean shell weight is 2.2 g.

The shell is slightly to moderately weathered. There is no indication of wind polish.

Table 9-47. Shellfish Remains from SBa-980.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	3.1	1.8	2.2	1
Haliotis sp.	0.4	0.2	n.d.	1
Acmaea mitra	1.7	1.0	1.0	1
Tegula sp.	71.3	40.5	32.8	33
Crepidula sp.	0.1	0.1	0.1	1
Nucella emarginata	0.1	0.1	0.1	1
Nucella sp.	0.4	0.2	n.d.	2
Cryptochiton stelleri	25.9	14.7	7.8	1
Polyplacophora, undifferentiated	1.0	0.6	n.d.	2
Mytilus californianus	70.1	39.8	25.2	16
Protothaca staminea	0.1	0.1	0.1	1
Pelecypoda, undifferentiated	1.2	0.7	n.d.	1
Balanus cariosus	0.1	0.1	n.d.	1
Pollicipes polymerus	0.3	0.2	n.d.	1
Cirripedia, undifferentiated	0.1	0.1	n.d.	1
Decapoda, undifferentiated	0.1	0.1	n.d.	1
Total	176.0		69.3+	

SBa-998: A small but diverse assemblage of shellfish remains is available from SBa-998 (Table 9-48). It comprises 22.9 g of shell representing eleven shellfish categories. Tegula sp. is the most abundant mollusk, forming 30.6 percent of the assemblage by shell weight. It is also the mollusk taken in greatest numbers by the aboriginal occupants of the site. Cryptochiton stelleri, Haliotis cracherodii, and Mytilus californianus are the next most common species by shell weight in the assemblage, each representing just over 20 percent of the sample.

Table 9-48: Shellfish Remains from SBa-998

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	5.0	21.8	3.6	1
Haliotis sp.	0.1	0.4	n.d.	1
Tegula sp.	7.0	30.6	3.2	11
Crepidula adunca	0.1	0.4	0.1	1
Nucella emarginata	0.2	0.9	0.2	1
Nucella sp.	0.1	0.4	n.d.	1
Cryptochiton stelleri	5.2	22.7	1.6	1
Polyplacophora, undifferentiated	0.2	0.9	n.d.	1
Mytilus californianus	4.7	20.5	1.7	22
Protothaca staminea	0.1	0.4	0.1	1
Balanus cariosus	0.2	0.9	n.d.	1
Total	22.9		10.5+	

The shellfish remains from this site are moderately weathered and quite fragmentary. However, there is no evidence of wind redeposition or polish.

SBa-1036: A total of 1.1 g of shell was obtained from SBa-1036 (Table 9-49). The assemblage includes Haliotis sp., Tegula sp., Mytilus californianus, and Balanus tintinnabulum. There is no indication of wind-polished surfaces, but the shell is moderately to badly eroded.

Table 9-49. Shellfish Remains from SBa-1036.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis sp.	0.4	36.4	0.3	1
Tegula sp.	0.3	27.3	0.1	1
Mytilus californianus	0.2	18.2	0.1	1
Balanus tintinnabulum	0.2	18.2	n.d.	1
Total	1.1		0.5+	

SBa-1038: SBa-1038 yielded 28.2 g of shellfish remains (Table 9-50). Nearly half of this total is composed of Tegula sp.; substantial but lesser proportions of the assemblage are accounted for by Mytilus californianus and Cryptochiton stelleri.

Table 9-50. Shellfish Remains from SBa-1038

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	1.2	4.3	0.9	1
Haliotis sp.	0.4	1.4	n.d.	1
Tegula sp.	13.2	46.8	6.1	7
Crepidula adunca	0.2	0.7	0.1	2
Cryptochiton stelleri	4.9	17.4	1.5	1
Polyplacophora, undifferentiated	0.3	1.0	n.d.	1
Mytilus californianus	7.6	27.0	2.7	4
Septifer bifurcatus	0.1	0.3	0.1	1
Mollusca, undifferentiated	0.1	0.3	n.d.	1
Decapoda, undifferentiated	0.2	0.7	n.d.	1
Total	28.2		11.4	

The remains are moderately weathered. There is no indication of wind polish.

SBa-1070: Tegula sp. is the major shellfish represented in the SBa-1070 asssemblage, accounting for nearly half of the sample by weight (Table 9-51). Mytilus californianus is the second most important species, forming nearly 40 percent of the assemblage. Small chitons and limpets are relatively well-represented although they are not a very large proportion of the remains by weight. Altogether, 26 shellfish categories are represented.

The mean Mytilus shell weight is 2.3 g; the Tegula mean shell weight is 1.7 g.

The shell from SBa-1070 is slightly to moderately eroded and shows no indication of wind polish.

SBa-1070E: SBa-1070E yielded a few fragments of shell from subsurface contexts (Table 9-52). All are moderately to badly weathered, but there is no indication of wear from wind-redeposition.

Three kinds of mollusks are represented: Tegula sp., Mytilus californianus, and an unidentified chiton. All were obtained from the rocky intertidal habitat.

SBa-1153: Shellfish remains from SBa-1153 total 0.8 g of shell representing four kinds of shellfish (Table 9-53). All are typical rock-perching forms.

Table 9-51. Shellfish Remains from SBa-1070.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	0.5	0.2	0.4	1
Haliotis sp.	0.1	*	n.d.	1
Acmaea mitra	0.2	0.1	0.1	1
Collisella pelta	1.1	0.5	0.9	3
Lottia gigantea	0.1	*	0.1	1
Acmaeidae, undifferentiated	2.1	0.9	n.d.	5
Tegula sp.	108.0	48.3	49.7	63
Crepidula adunca	0.6	0.3	0.4	8
Crepidula sp.	0.1	*	0.1	1
Nucella emarginata	0.1	*	0.1	1
Nucella canaliculata	0.3	0.1	0.2	1
Nucella sp.	0.2	0.1	n.d.	1
Gastropoda, undifferentiated	0.1	*	n.d.	1
Cryptochiton stelleri	1.5	0.7	0.5	1
Polyplacophora, undifferentiated	5.5	2.5	n.d.	6
Mytilus californianus	88.6	39.6	31.9	38
Septifer bifurcatus	3.7	1.7	2.0	5
Hinnites multirugosus	2.5	1.1	n.d.	1
Protothaca, staminea	0.5	0.2	0.3	1
Pelecypoda, undifferentiated	0.4	0.2	n.d.	1
Mollusca, undifferentiated	0.1	*	n.d.	1
Balanus cariosus	4.3	1.9	n.d.	1
Balanus glandula	0.1	*	n.d.	1
Pollicipes polymerus	2.2	1.0	n.d.	5
Cirripedia, undifferentiated	0.2	0.1	n.d.	1
Decapoda, undifferentiated	0.5	0.2	n.d.	1
Total	223.6		86.7+	

Table 9-52. Shellfish Remains from SBa-1070E.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Tegula sp.	0.1	25.0	*	1
Polyplacophora, undifferentiated	0.2	50.0	n.d.	1
Mytilus californianus	0.1	25.0	*.	1
Total	0.4		0.1+	

Table 9-53. Shellfish Remains from SBa-1153.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Tegula sp.	0.1	12.5	*	1
Polyplacophora, undifferentiated	0.2	25.0	n.d.	1
Mytilus californianus	0.4	50.0	1.4	1
Pollicipes polymerus	0.1	12.5	n.d.	1
Total	0.8		1.4+	

Fieldwork at SBa-1153 resulted in the definition of two discrete areas of occupation debris, designated SBa-1153 North and SBa-1153 South (Haley and Serena 1980:2.4-2.6, 3.2). The shellfish remains were excavated from SBa-1153 North, and match precisely the list of shell types observed on the surface of the site. A more varied assemblage was noted at SBa-1153 South; it included Haliotis cracherodii, Mytilus californianus, Tegula funebralis, Nucella emarginata, Collisella sp., and an unidentifiable chiton (Haley and Serena 1980:2.5).

The shellfish remains from SBa-1153 are moderately weathered but display no wind polish.

SBa-1154: A single, disk-shaped Haliotis sp. nacre bead, recovered from the surface, is the only shell item collected from the site (Table 9-54). When found, the artifact was in a state of advanced deterioration due to wind weathering; it has since decomposed completely in storage. Photographs of the artifact made in the field show the bead to have been 1.2 cm in diameter, with a round central perforation 0.3 cm across. Slight curvature of the disk suggests that it was made from a portion of the abalone shell near the excurrent openings. Species observed at the site but not represented in the collection include Cryptochiton stelleri and Mytilus californianus.

Table 9-54. Shellfish Remains from SBa-1154.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis sp.	0.1	100.0	n.d.	1
Total	0.1		n.d.	

SBa-1173: The shell assemblage from SBa-1173 consists of one Cryptochiton stelleri fragment and one Mytilus californianus fragment, totaling 1.7 g (Table 9-55). Both exhibit extreme edge-rounding and polishing from the wind, and have therefore probably been redeposited.

Table 9-55. Shellfish Remains from SBa-1173.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Cryptochiton stelleri	1.6	94.1	0.48	1
Mytilus californianus	0.1	5.9	*.	1
Total	1.7		0.48+	

SBa-1174: SBa-1174 is comprised of one or more prehistoric components and an historic Euroamerican component. Nearly all of the shell can be attributed to the Euroamerican occupation on the basis of the virtually unweathered condition of the remains. The few grams of shell not clearly derived from the historic occupation are fairly well-preserved and consequently of ambiguous origin; that is, it cannot be determined by examination if they are derived from the historic occupation or a prehistoric component. The entire assemblage is therefore treated as a product of the Euroamerican occupation, with the understanding that the ambiguous remains are only a tiny fraction of the collection and do not significantly affect interpretation of the assemblage as a whole.

The major species represented in the sample is Haliotis cracherodii, forming over two-thirds of the assemblage by weight (Table 9-56). The abalone shell, like virtually all of the shellfish remains in the collection, is in excellent condition. The fragments are large, the nacreous calcium carbonate is intact and lustrous, and the coloring of the epidermis is essentially unchanged from that of fresh specimens. Individually, all of the abalones are large, indicating careful size selection.

Tivela stultorum and Mytilus californianus are the second and third most abundant species in the collection, respectively. They are represented by large individuals only; for example, each of the six mussels in this sample is larger than any Mytilus specimen recovered from prehistoric contexts studied as part of the MX-related archaeological research. The extraordinary size of these animals bespeaks the pattern of large size selection practiced by the Euroamerican occupants of the site, and may indicate as well the recovery of local mussel beds from the intensive exploitation practiced by the aborigines.

Table 9-56. Shellfish Remains from SBa-1174.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	483.3	68.2	343.1	8
Haliotis sp.	1.3	0.2	n.d.	1
Tegula sp.	4.6	0.6	2.1	2
Mytilus californianus	95.3	13.5	34.3	6
Tivela stultorum	122.7	17.3	27.0	5
Protothaca staminea	0.2	*	0.1	1
Pelecypoda, undifferentiated	0.5	0.1	n.d.	1
Mollusca, undifferentiated	0.2	*	n.d.	1
Decapoda, undifferentiated	0.4	0.1	n.d.	1
Total	708.5		406.6+	

Minor amounts of Tegula sp., Protothaca staminea, an unidentified crab, and undifferentiated shell round out the collection. These minor constituents appear largely to be associated with the historic component based on their relatively unweathered condition.

SBa-1177: SBa-1177 yielded 1.7 g of marine shell representing at least three different kinds of shellfish (Table 9-57). All of these are rock-perching mollusks. The material is moderately weathered, but shows no indication of wind damage.

Table 8-57. Shellfish Remains from SBa-1177.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Acmaeidae, undifferentiated	0.4	23.5	n.d.	1
Tegula sp.	0.9	52.9	0.4	1
Mytilus californianus	0.3	17.6	0.1	1
Mollusca, undifferentiated	0.1	5.9	n.d.	1
Total	1.7		0.5+	

SBa-1179: The shell assemblage from SBa-1179 is by far the largest of any in the collections (Table 9-58). A total of 6,734.8 g of shell is present, of which Mytilus californianus accounts for 6,227.7 g or 92.5 percent. The other 25 shellfish categories represented in the assemblage are present in

trace amounts only. Some of these, including the Tegula sp. and limpets, were clustered together in the southeast corner of the excavated area, suggesting that they were either collected at a different time or disposed of in a different manner than the Mytilus.

The Mytilus valves are of a relatively uniform, small size. The mean Mytilus shell weight is 2.3 g. Tegula mean shell weight is a mere 1.2 g.

A Platyodon cancellatus valve with a chipped and worn margin appears to have been used as a scraping tool. This is the only shell in the assemblage displaying evidence of deliberate use or modification.

Table 9-58. Shellfish Remains from SBa-1179.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	97.5	1.4	69.2	1
Haliotis rufescens	57.0	0.8	n.d.	1
Haliotis sp.	0.5	*	n.d	1
Collisella pelta	0.6	*	0.5	2
Collisella digitalis	0.1	*	0.1	1
Collisella asmi	0.1	*	0.1	1
Acmaeidae, undifferentiated	2.5	*	n.d.	14
Tegula sp.	104.1	1.5	47.9	90
Crepidula sp.	0.1	*	0.1	1
Nucella emarginata	1.0	*	0.9	3
Nucella canaliculata	8.2	0.1	6.2	15
Nucella sp.	0.6	*	n.d.	3
Cryptochiton stelleri	1.2	*	0.4	1
Polyplacophora, undifferentiated	16.2	0.2	n.d.	18
Mytilus californianus	6227.7	92.5	2242.0	2737
Platyodon cancellatus	23.4	0.3	n.d.	1
Protothaca, staminea	0.6	*	0.4	1
Pholadidae, undifferentiated	0.1	*	n.d.	1
Pelecypoda, undifferentiated	6.2	0.1	n.d.	2
Mollusca, undifferentiated	0.9	*	n.d.	1
Balanus cariosus	16.7	0.2	n.d.	7
Balanus glandula	7.4	0.1	n.d.	21
Balanus tintinnabulum	98.3	1.5	n.d.	76
Tetraclita squamosa	2.4	*	n.d.	2
Pollicipes polymerus	14.9	0.2	n.d.	7
Cirripedia, undifferentiated	46.5	0.7	n.d.	57
Total	6734.8		2367.8+	

The shell is slightly to moderately weathered, without any indication of wind polish.

SBa-1181: The shell assemblage from SBa-1181 consists of 0.1 g of unidentified mollusk shell (Table 9-59). The fragment appears to be wind-polished.

SBa-1193: SBa-1193 yielded 3.9 g of shellfish remains. Haliotis cracherodii is the best-represented species, although fragments of Mytilus californianus and unidentifiable mollusk shell are present (Table 9-60). The remains are slightly to moderately weathered and show no indication of wind polish.

Table 9-59. Shellfish Remains from SBa-1181.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Mollusca, undifferentiated	0.1	100.0	n.d.	1
Total	0.1		n.d.	

Table 9-60. Shellfish Remains from SBa-1193.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	3.6	92.3	2.6	1
Mytilus californianus	0.2	5.1	0.1	1
Mollusca, undifferentiated	0.1	2.6	n.d.	1
Total	3.9		2.7+	

SBa-1709-H (RTF): SBa-1709-H yielded 95.5 g of shellfish remains associated with the Euroamerican occupation of the site (Table 9-61). The assemblage is divisible into two parts: waterworn shell, including all of the Olivella biplicata, Penitella penita, and undifferentiated pelecypod; and non-waterworn shell, including the Haliotis cracherodii and Protothaca staminea. The former group is composed of shells obtained from a beach deposit and transported to the site either deliberately or as an incidental constituent of sand fill. The latter group is composed of probable food remains.

Table 9-61. Shellfish Remains from SBa-1709-H (RTF).

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	45.1	47.2	32.0	1
Olivella biplicata	5.6	5.9	n.d.	8
Protothaca staminea	5.1	5.3	3.1	2
Penitella penita	4.3	4.5	n.d.	1
Pelecypoda, undifferentiated	35.4	37.1	n.d.	2
Total	95.5		35.1+	

The Haliotis and Protothaca shells are only slightly weathered and are believed to have been recently deposited. This conclusion is substantially reinforced by the recovery of desiccated soft tissue attached to some shells in the collection. Haliotis and Protothaca are currently among the most popular shellfish sought by local collectors, and might be considered a typical modern assemblage.

SBa-1718: SBa-1718 yielded 146.6 g of shellfish remains, of which nearly two-thirds is Mytilus californianus (Table 9-62). Barnacles of different types are relatively abundant, together accounting for about one-fifth of the remains by weight. Tegula sp. forms only 7.1 percent of the assemblage by weight. The assemblage is dominated by rock-perching mollusks.

The mean shell weight of Mytilus is 3.5 g; that of Tegula is 1.3 g.

The shell is moderately to badly eroded. A few fragments of prismatic Mytilus shell appear to be wind-polished; however, the bulk of the shell shows no such damage and was probably in situ when excavated.

SBa-540: The shellfish assemblage from SBa-540 is composed of 0.4 g of Balanus tintinnabulum shell, representing portions of two compartments (Table 9-63). Both fragments are badly weathered and appear to be wind-polished.

SBa-1683: SBa-1683 yielded 0.2 g of Tegula sp. shell (Table 9-64). The shell is moderately weathered but displays no indication of wind damage

SBa-1753: Shellfish remains from SBa-1753 comprise a single Olivella biplicata bead of the full-lipped type (Table 9-65). The bead diameter is 0.85 cm and the perforation is 0.33 cm across. The bead, recovered from the surface, is highly wind-polished.

Full-lipped beads are generally considered diagnostic of the Late Period, A.D. 1150 or later.

Table 9-62. Shellfish Remains from SBa-1718.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Acmaeidae, undifferentiated	0.3	0.2	n.d.	2
Tegula sp.	10.4	7.1	4.8	8
Nucella emarginata	1.4	1.0	1.2	2
Olivella biplicata	0.2	0.1	n.d.	1
Gastropoda, undifferentiated	0.4	0.3	n.d.	1
Polyplacophora, undifferentiated	0.2	0.1	n.d.	1
Mytilus californianus	97.2	66.3	35.0	28
Tivela stultorum	3.5	2.4	0.8	1
Protothaca staminea	1.9	1.3	1.2	1
Pelecypoda, undifferentiated	0.5	0.3	n.d.	1
Mollusca, undifferentiated	2.0	1.4	n.d.	2
Balanus cariosus	6.2	4.2	n.d.	1
Balanus glandula	0.2	0.1	n.d.	1
Balanus tintinnabulum	0.8	0.5	n.d.	1
Tetraclita squamosa	1.0	0.7	n.d.	1
Pollicipes polymerus	2.3	1.6	n.d.	2
Cirripedia, undifferentiated	18.2	12.4	n.d.	5
Decapoda, undifferentiated	0.1	0.1	n.d.	1
Total	146.6		43.0+	

Table 9-63. Shellfish Remains from SBa-540.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Balanus tintinnabulum	0.4	100.0	n.d.	1
Total	0.4		n.d.	

Table 9-64. Shellfish Remains from SBa-1683.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Tegula sp.	0.2	100.0	0.1	1
Total	0.2		0.1	

Table 9-65. Shellfich Remains from SBa-1753.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Olivella biplicata	0.1	100.0	n.d.	1
Total	0.1		n.d.	

Locus A: Locus A, an area investigated as a possible archaeological site (Haley and Serena 1980:2.1), yielded a single, fragmentary Mytilus californianus valve from the surface (Table 9-66). This is the only item of possible prehistoric cultural origin found at Locus A. Badly weathered and wind-polished, the mussel valve may have been transported by the wind from another location, perhaps an archaeological deposit in the vicinity, such as SBa-1154.

Unprovenienced VTN Collections: The shellfish remains in unprovenienced collections made by archaeologists employed by VTN Consolidated comprise 2.1 g of mollusk shell (Table 9-67). The Haliotis Cracherodii and Mytilus californianus fragments are only slightly weathered by the wind, suggesting that they were not exposed for a very long time prior to collection. The undifferentiated pholad shell is waterworn and probably does not represent the gathering of shellfish for food.

Table 9-66. Shellfish Remains from Locus A.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Mytilus californianus	1.0	100.0	0.4	1
Total	1.0		0.4	

Table 9-67. Shellfish Remains from Unprovenienced VTN Collections.

Scientific Name	Shell Weight (g)	Percent	Estimated Meat Weight (g)	MNI
Haliotis cracherodii	0.4	19.0	0.3	1
Mytilus californianus	0.3	14.3	0.1	1
Pholadidae, undifferentiated	1.4	66.7	n.d.	1
Total	2.1		0.4+	

Conclusions

Prehistoric Activities Indicated by Shellfish Remains: Virtually all of the shellfish remains from prehistoric sites considered in this report represent the collecting of shellfish from rocky intertidal areas for use as food. It is important to note that none of the sites is situated so as to make shellfish procurement particularly convenient; all are located about 5 km or farther from the nearest mussel beds. This indicates that shellfish were not the focus of activities at the sites, but rather were obtained for the maintenance of people engaged primarily in other activities.

There is no evidence at any site that shells were used as raw material for the production of tools or ornaments. A few manufactured tools and ornaments were brought to the sites, having presumably been produced elsewhere. These include two shell beads and a fishhook fragment (see Table 9-68). A clamshell "scraper," a tool not requiring any modification prior to use, was found at SBa-1179. The paucity of shell beads in the assemblages--particularly those dated on the basis of projectile point types to the late period (as defined in the analysis of chipped stone)--suggests that the social functions often associated with these artifacts were not important at the sites under consideration. The presence of a fishhook fragment at SBa-706 indicates that some fishing was done by the occupants of this site, although the intensity of this activity cannot be determined.

Season of Occupation: The presence of a fairly large proportion of Cryptochiton stelleri shell in the SBa-980 assemblage suggests that this site may have had a spring occupation. The absence of Cryptochiton in an assemblage is not interpretable as evidence that a site was not occupied during the spring. SBa-980 is the only site at which shellfish remains yield information on the season of occupation.

Shellfish Remains and Regional Settlement Patterns

Assemblage Diversity and Duration of Site Occupation: Assemblage diversity is defined by the number and relative proportions of species collected to fulfill the desire for shellfish. There is a direct relationship between assemblage diversity and the duration of occupation at sites where shellfish collecting is a regular activity. Occupations of long duration should yield assemblages more diverse than occupations of short duration.

Table 9-68. Shell Tools and Ornaments.

Location	Description
SBa-1753	Full-lipped *Olivella biplicata* bead; Late Period (in terms of King's chronology)
SBa-1154	*Haliotis* sp. nacre bead; probably Late Period
SBa-1179	*Platyodon cancellatus* valve with chipped and worn edge; not temporally sensitive
SBa-706	*Mytilus californianus* fishhook fragment; Middle or Late Period

Shellfish collectors encounter a variety of intertidal water conditions through the year that affect their collecting activities. For example, winter low tides may expose relatively unexploited portions of mussel beds where collecting can be pursued more efficiently than in places where mean animal size has been reduced by collecting pressure. Storm surfs may limit access to all but the uppermost reaches of the intertidal zone. In general, more variation in water conditions is likely to be encountered over a long period of time than over a short time. Shellfish collecting under the varying conditions encountered in the long term will tend to produce variable assemblages.

A second link between assemblage variability and the duration of site occupation lies in the inability of a small part of the intertidal zone to absorb regular exploitation without becoming seriously degraded. It is inefficient to exploit degraded shellfish beds because prey species suffer reduced populations and depressed mean animal size. The result is that collectors working over a long period of time will, in order to maintain efficiency if not to "manage" consciously the resource, tend to operate over a large area. This dispersal of effort over a large area of the intertidal zone will tend to expose collectors to a variety of shellfish habitats supporting different kinds of communities, thus increasing the variability of the "catch" and the resulting archaeological assemblage.

An Index of Assemblage Diversity: An index of assemblage diversity has been formulated for use with the assemblages under consideration. This index focuses on the major shellfish categories in each assemblage, ignoring trace species whose presence is largely incidental. The index is produced by summing the following shell weight percentages:

1. The percentage of the best-represented shellfish category in the assemblage;

2. The combined percentages of the two best-represented shellfish categories in the assemblage; and

3. The combined percentages of the three *best-represented shellfish* categories in the assemblage.

The maximum possible score is 300 (where 100 percent of the assemblage is represented by a single species); the minimum score approaches zero. Thus scores increase with decreasing diversity and vice versa. Scores for all assemblages with more than 100.0 g of shell have been calculated and are presented in Table 9-69.

Site Locations and Assemblage Diversity: There are five prehistoric assemblages with total shell weights exceeding 100.0 g. In order of greatest to least assemblage diversity these sites are: SBa-706, -980, -1070, -1718, and -1179. The first three are large sites located within 1 km of the margin of the San Antonio Terrace; the last two are small sites located in the central dunes. All of the sites are located about 5 km from the nearest mussel beds. Table 9-69. Selected Attributes of Sites with Shell Samples Greater than 100 Grams.

If this small sample of sites is representative of the settlement pattern in the San Antonio Terrace, then sites around the terrace margin were characterized by occupations of long duration, while sites in the central dunes were characterized by occupations of shorter duration. One possible interpretation is that the terrace margin sites served as basis from which smaller groups moved to sites in the central dunes.

The only early period site yielding more than 100.0 g of shell is SBa-1718. The assemblage is very similar to that from SBa-1179, a recent period site also in the central portion of the intermediate dunes (Table 9-69). This close similarity, and the marked differences between central dunes sites and terrace margin sites suggest that the settlement pattern persisted at least from the early period through the recent period. The increase in recent period components could indicate an intensification of use of the terrace, or differential preservation of sites of different periods.

Euroamerican assemblages indicate greatly reduced pressure on shellfish resources and a related shift in emphasis to different species, particularly the black abalone. Low assemblage diversity and large animal sizes indicate that only a narrow range of acceptable animals was targeted for collection, as opposed to the more generalized collecting habits of the aborigines.

ANALYSIS OF OSSEOUS FAUNAL REMAINS

Approach to the Anlaysis

The analysis of the vertebrate faunal remains from the San Antonio Terrace Collections focussed on two major sets of research questions, one dealing with the identification of depositional processes, and the other with subsistence and settlement patterns.

Depositional Processes: In analyses aimed at interpreting archaeological sites, the preliminary question of whether the collection is in fact the product of cultural rather than natural processes is often overlooked. In an active

Table 9-69. Selected Attributes of Sites with Shell Samples Greater than 100 Grams.

Site	Mytilus Mean Shell Weight (g)	Tegula Mean Shell Weight (g)	Percent Mytilus	Percent Tegula	Percent All Limpet	Percent Crypto-Chitons	Percent Other Chitons	Percent All Haliotis	Assemblage Diversity Index	Period of Occupation
SBa-706	3.6	2.2	47.4	31.3	0.3	4.8	1.6	7.3	213	recent
SBa-980	4.4	2.2	39.8	40.5	1.0	14.7	0.6	2.0	216	recent
SBa-1070	2.3	1.7	39.6	48.3	1.6	0.7	2.5	0.3	227	recent
SBa-1179	2.3	1.2	92.5	1.5	*	*	0.2	2.3	282	recent
SBa-1718	3.5	1.3	66.3	7.1	0.2	---	0.1	---	231	early
SBa-1174	15.9	2.3	13.5	0.6	---	---	---	68.4	253	historic

*present, less than 0.1 percent of assemblage

dune area such as that of the San Antonio Terrace, it is especially important to attempt to distinguish between the effects of human behavior and the effects of wind, moving sand, and other environmental factors on the distribution and characteristics of vertebrate faunal remains.

Natural processes may affect the faunal remains recovered archaeologically in a variety of ways. They may serve to introduce non-cultural remains, transport cultural remains either into or out of a deposit, or modify the size, shape, color, and surface characteristics of bone fragments. Some of the more obvious natural processes which could have affected the bone recovered during the San Antonio Terrace testing and mitigation program include: the death of local dune fauna by natural causes; the activities of rodents and carnivores; wind; and brush fires. This list is by no means exhaustive. The contribution of such processes to the faunal assemblage can be tested in a variety of ways. Although no single line of evidence is sufficient to prove or disprove the involvement of natural processes, the coincidence of several different lines can be persuasive. The following tests were employed in this analysis.

1. Fragment Size and Weight. The ability of wind to move fragments of bone is limited by the weight and size of the fragment. If the presence of bone is primarily the result of aeolian processes, there should be a predominance of small, lightweight fragments. It should be noted that the inverse of this argument does not follow automatically since other factors, such as exposure to weathering, trampling, and the activities of burrowing animals may also result in the fragmentation of bone.

2. Abundance and Skeletal Completeness of Local Dune Fauna. If the faunal assemblage is largely the result of natural deaths, there should be a predominance of complete skeletons of small, local dune fauna.

3. Ranking of Sites. If wind is a significant depositional process for the San Antonio Terrace as a whole, sites which are closer to the coast and more exposed to the wind should have a higher percentage of small, lightweight, abraded fragments than should sites which are more protected and located more inland.

4. Burning. Either cultural or natural processes or both may contribute to the presence of burned bone in a deposit. In order to differentiate cultural from natural burning the excavational context was evaluated. If the burned bone was associated with a concentration of other cultural artifacts and evidence of burning, it was considered cultural. If the burned fragments were uniformly small and lightweight, and occurred in low frequency, deposition by wind was suggested.

Two additional tests were used to identify sites with clear cultural components:

1. Presence of Non-Dune Fauna. The presence of fish or sea mammal bone in dune sites cannot be explained as the result of natural deaths. The skeletal remains of fauna not indigenous to the dune environment were considered clear evidence of cultural processes.

2. Presence of Butchering Marks. The presence of butchering marks was also considered unambiguous evidence of cultural activity.

Subsistence and Settlement Patterns: Three aspects of subsistence and settlement patterns were approached: site function, exploitation strategy, and seasonality. The diversity of the fauna represented, the relative emphasis on different faunal resources, and the distribution of body parts per taxon were evaluated to identify site function and exploitation strategy. The question of seasonality was to be approached through the identification of migratory waterfowl and the thin-sectioning of teeth; neither of these proved feasible due to the complete lack of migratory waterfowl bone and the fragmentary nature of the few teeth which were recovered. The assumptions made and the types of data used to answer questions of site function and exploitation strategy are presented below.

1. Faunal Diversity. It has been suggested in the research design that the diversity of faunal resources represented at a site is an indicator of the complexity of site function. A wide variety of resources would be expected at base camps while an emphasis on few resources would be typical of field camps. Little or no faunal remains would characterize special activity sites, except those devoted to hunting and butchering. In order to measure the diversity of faunal resources, the bone material from each site was identified to the most specific taxonomic level possible. Sites were then compared in terms of the number of taxonomically distinct categories represented.

2. Relative Emphasis on Different Faunal Resources. The relative emphasis on different faunal resources is relevant to considerations of dietary importance, the extent to which different habitats were exploited, and hunting or collection strategies. To evaluate relative emphasis, the bone was counted and weighed, and relative percentages of each taxonomic group were calculated. Special attention was paid to differences between local and non-local fauna, and to differences between small and large fauna.

3. Distribution of Body Parts Per Taxon. Patterning in the distribution of body parts can help identify stages in the processing of faunal resources. To identify such patterning, each identified species was sorted into skeletal elements and a tabulation made of the number of each element present.

Methods

All vertebrate faunal material was received from CCP boxed by site and, within each site, bagged by lot. All analysis of the bone was performed by a single analyst at the UCSB faunal analysis lab.

Material was processed by lot for each site. The bone from each lot was sorted first by size category, determined by maximum surface area, and then evaluated, fragment by fragment, in terms of the degree of burning, the degree of abrasion, the presence or absence of butchering marks, the type of weathering, and the nature of any other form of modification. Each fragment was then weighed and identified to the most specific taxonomic level possible and to the side and portion of the skeletal element represented. When the bone could be identified as belonging to an immature individual, this was also noted. An explanation of the criteria and equipment used to evaluate each of these variables is given below.

Size Category: Each fragment of bone was measured individually as to its maximum two-dimension size. This was accomplished by sliding the fragment over a series of 32 circles of known diameter which had been drawn on a sheet of paper using a Berol Rapid Design No. 2140 template. These circles ranged in diameter from 3 to 50 mm. Fragments with a maximum dimension greater than 30 but less than or equal to 35 were collapsed into the size category of 35 mm. A similar procedure was followed for the size categories of 40 mm, 45 mm, and 50 mm, which included the actual size ranges of 36 to 40 mm, 41 to 45 mm, and 46 to 50 mm respectively. Fragments with a maximum dimension greater than 50 mm were measured with sliding calipers.

Although fragments were originally measured in terms of millimeters of maximum dimension, size values which appear in the tables and the text are given in terms of the screen size, measured in fractions of an inch, through which a fragment would or would not go. This was done to facilitate comparison with data presented elsewhere on the size distribution of chipped stone flakes, which were sorted by screening.

The conversion was made in the following manner. The length of the diagonal of a square of the given screen size was calculated and converted from fractions of an inch to millimeters; the diagonal, rather than the sides, of the square was used because the diagonal represents the maximum opening through which a fragment might pass. The difference is small, but it is significant in terms of millimeters. The bone fragment size data were then collapsed. Fragments whose maximum dimensions were less than the lengths of the diagonals of the various screen sizes were grouped together in the following way:

Maximum Dimension	Screen Size
Less than or equal to 4 mm	Less than 1/8 inch
5 to 9 mm	Less than 1/4 inch
10 to 18 mm	Less than 1/2 inch
Greater than or equal to 19 mm	Greater than or equal to 1/2 inch

Flakes retained in a screen after shaking actually represent minimum rather than maximum dimension; when comparing size distributions of bone and chipped stone fragments, it should be kept in mind that the chipped stone flakes may tend to have slightly larger maximum dimensions than bone fragments in the same size category.

The purpose of measuring fragment size was to facilitate the testing of hypotheses concerning the movement of bone fragments by wind.

Burning: Each fragment was ranked as either extremely burned (2), slightly burned (1), or not burned at all (0). Bone was considered extremely burned if it had a charred black color or a chalky, blue-white character. Bone was identified as slightly burned if it was darkened to a deep brown and/or possessed hardened, shiny surfaces. Bone was designated as not burned if it lacked the above characteristics.

The purpose of evaluating the presence or absence of burned bone was to facilitate the testing of hypotheses concerning cultural activity. Although bone may be burned by natural processes such as brush fires, in certain contexts burned bone can contribute to the interpretation of subsistence and settlement patterns.

Butchering Marks: Each fragment was examined for evidence of butchering and assigned to one of four categories. When cut marks were short and shallow and occurred at places of muscle, ligament, or tendon attachment, the butchering was coded as Type 1. Type 1 butchering marks were also characterized by their tendency to have edges which were somewhat uneven and to occur in groups of two or more, parallel to each other. Type 2 butchering marks included cuts that were long and deep and those which went completely through the bone and resulted in a planar surface, often transverse to the natural axis of the bone or one of its processes. Type 3 butchering marks included those which did not fall clearly into either Type 1 or Type 2. The fourth category coded for the absence of butchering marks.

The purpose of evaluating butchering marks was to facilitate the testing of hypotheses about cultural activity. The presence of butchering marks is a clear indicator of human activity. Type 2 butchering marks are associated with the use of metal tools, while Type 1 marks are associated, although not exclusively, with the use of stone tools. The presence of Type 2 butchering marks aids in the identification of historic sites.

Other Modification: Each bone fragment was evaluated for evidence of other types of modification, both natural and cultural. Five categories were used: 1) rodent gnawing; 2) carnivore gnawing; 3) mixed or undifferentiated gnawing; 4) cultural modification; and 5) the absence of the above forms of

modification. Rodent gnawing was characterized by a series of pairs of shallow, adjacent, and parallel grooves whose widths matched those of the incisors of local rodents. Carnivore gnawing was characterized by rough, circular puncture marks or indention whose sizes matched those of the canines of local carnivores, and by rough, somewhat rounded edges, where the margins of the bone demonstrated neither spiral fracture, step fracture, nor the uniform smoothness of weathering. Mixed or undifferentiated gnawing was characterized by a combination of both rodent and carnivore marks or by marks which did not fall clearly into one or the other of those two categories. Cultural modification other than butchering was characterized by ground, straight-cut edges and highly polished surfaces occurring on fragments which demonstrated an unnatural symmetry or shape.

The purpose of identifying these other forms of modification was to contribute to the understanding of processes of site formation. Rodent and carnivore gnawing indicate the influence of natural processes on the distribution of faunal remains. The presence of culturally modified bone is obviously an indicator of the influence of cultural processes.

Weight: Each fragment of bone was weighed to the nearest hundredth of a gram on an Ohaus 1500D electronic scale. Fragments which weighed less than 0.01 g were recorded as 0.01 g; this had the effect of creating weight totals which may be recorded as being a few hundredths of a gram higher than they actually are.

The purpose of weighing individual fragments was to facilitate the testing of hypotheses concerning the effects of wind on the distribution of bone.

Taxonomic Identification: Each fragment of bone was identified to the most specific taxonomic level possible.

First, a baseline list of expected species was developed, using "Ecological Assessment of Vandenberg Air Force Base, Volume II, Biological Inventory 1974/75" (Cooper and Coulombe 1976), and Ingles' (1965) "Mammals of the Pacific States." Then a comparative collection of representative osteological specimens was assembled, using the resources of the UCSB faunal analysis lab and the Santa Barbara Museum of Natural History.

The general procedure followed was first to identify the skeletal element represented and the broad taxonomic category to which it belonged, such as fish, reptile, bird, or mammal, and then to use the size of the element and the details of its features to define the relatively few species to which it could belong. In many cases the bone fragments did not possess enough specific features to allow identification beyond a broad category such as "rodent" or "large mammal." When specific features were present the comparative collection was used to assure proper identification.

The following is a list of the broad taxonomic categories employed and the criteria used to define them. Identification to the genus and species levels was dependent upon the use of the comparative collection and a direct matching of bone to bone.

Fish: Amphicoelous vertebrae; identifiable cranial elements.

Reptile: Opisthocoelous vertebrae.

Bird: Identifiable articular ends; elements unique to birds, such as coracoids; shaft fragments whose cortical bone was exceptionally thin in relationship to the diameter of the shaft, and which possessed a dense, smooth outer surface and lacked cancellous bone.

Rodent, undifferentiated: Teeth, cranial and madibular elements, limb bones, and articular ends of limb bones, whose characteristics were clearly those of mammals and whose size was less than that of a brush rabbit.

Lagomorph, undifferentiated: Teeth, cranial and mandibular elements, limb bones, and articular ends of limb bones, whose characteristics were clearly those of lagomorphs but whose size and features did not permit a distinction between jackrabbit, brush rabbit, and desert cotton tail.

Small mammal, undifferentiated: Teeth, cranial elements, articular ends of limb bones, platyan vertebrae, and shaft fragments, whose size and features were clearly those of mammals less than or equal in size to a jackrabbit, and which could not be clearly identified as either rodent or lagomorph.

Small animal, undifferentiated: Any bone fragment which could be identified as belonging to an animal less than or equal in size to a jackrabbit, and which could not be clearly differentiated into reptile, bird, or mammal categories.

Small/medium mammal, undifferentiated: Any bone fragment which could be identified as belonging to a mammal less than or equal in size to a coyote, and which could not be clearly differentiated into small or medium mammal.

Medium mammal, undifferentiated: Teeth fragments, cranial elements, articular ends of limb bones, platyan vertebrae, and shaft fragments, whose size and features were clearly those of mammals larger than jackrabbits and smaller than mule deer, and which could not be clearly identified as to genus and species. A coyote would be representative of the size of mammals included in this category.

Medium/large mammal, undifferentiated: Any bone fragment which could be identified as belonging to a mammal the size of or larger than a coyote, and which could not be clearly differentiated into medium or large mammal.

Medium ungulate, undifferentiated: Teeth fragments, cranial elements, and articular ends of limb bones, which were clearly those of deer, goat, or sheep, and which could not be identified as to genus and species.

Large ungulate, undifferentiated: Teeth fragments, cranial elements, and articular ends of limb bones, which were clearly those of cow or pig, and which could not be identified as to genus and species.

Sea mammal: Metapodials, phalanges, and articular ends of large limb bones, which were clearly those of a sea mammal.

Large mammal, undifferentiated: Teeth fragments, cranial elements, articular ends of limb bones, platyan vertebrae, and rib and shaft fragments whose size and features were clearly those of mammals greater than or equal in size to a mule deer, and which could not be clearly identified as an ungulate or as to genus and species.

Unidentifiable: Any bone fragment which lacked identifiable articular surfaces or other features and which was too small to permit an assessment of the size of the animal represented.

Although these categories are to some extent logically hierarchical, it is important to recognize that they are defined so as to be mutually exclusive. Any given bone fragment can belong to one and only one category. The category "small animal, undifferentiated," for example, does not include any bone which could be more precisely categorized as "small mammal, undifferentiated."

For the purposes of generalization (see Table 9-70) the various taxonomic categories were grouped together into four broader categories, which are defined below.

1. Small Fauna: All rodents, all lagomorphs, undifferentiated small mammals, undifferentiated small animals, reptiles, and birds.

2. Medium Fauna: Undifferentiated small/medium mammals, *Canis* sp., *Lynx rufus*, and undifferentiated medium mammals.

3. Large Fauna: *Odocoileus hemionus*, *Ovis/Capra*, undifferentiated medium ungulates, undifferentiated medium/large mammals, *Sus scrofa*, *Bos taurus*, undifferentiated large ungulates, and undifferentiated large mammals.

4. Fish and Sea Mammal: Fish and sea mammal were grouped together and separated from the other categories because they represent a distinctly different environment and exploitation strategy.

Table 9-70. Summary of General Site Characteristics.

SBa-Site Number	Total Bone Count	Total Bone Weight (To Nearest Hundredth of a Gram)	Volume Excavated (In Cubic Meters)	Density (Bone Count Per Cubic Meter)	Small Fauna Predominate (50% of Bone By Count)	Small Fragments (1/4 Inch In Size) Predominate	Fish or Sea Mammal Bone Present	Deer Bone Present	Burned Bone Present	Butchered Bone Present	Domestic Bone Present	Diversity (# of District Taxons Represented)
704	2	0.25	.21	10	+	-	-	-	-	-	-	1
706	1449	124.60	17.20	133	+	+	+	+	+	+	-	9
980	81	3.89	2.98	20	+	+	-	-	+	-	-	4
998	30	4.09	8.26	4	+	+	-	-	+	-	-	4
1036	186	39.73	23.95	9	+	+	-	-	+	-	+	8
1037	11	1.07	0.25	44	+	+	-	-	+	-	-	2
1038	13	0.83	4.31	3	+	-	-	-	-	-	-	3
1052	14	0.32	0.23	12	+	-	-	-	+	-	-	2
1070	31	2.61	2.34	13	-	+	+	+	+	-	-	3
1070E	6	0.09	3.13	2	+	+	-	-	-	-	-	5
1155	63	8.34	9.51	7	+	+	-	-	+	+	-	4
1170	3	1.01	4.82	1	+	-	-	-	-	-	-	2
1174	847	1772.17	6.70	126	-	-	+	+	+	+	+	14
1177	27	3.88	33.55	1	+	-	-	-	+	-	-	4
1179	550	48.74	48.89	27	+	+	+	+	+	-	-	8
1180S	1	116.78	2.86	1	-	-	-	-	-	-	+	4
1193	83	1.91	67.91	1	+	+	-	-	+	-	-	5
1682	4	0.15	3.46	1	-	+	-	-	+	-	-	1
1683	8	0.35	2.22	4	+	+	-	-	-	-	-	1
1718	133	4.03	5.84	17	+	+	-	-	+	-	-	4

The purpose of taxonomic identification was to facilitate the testing of hypotheses concerning the prehistoric use of faunal resources on the San Antonio Terrace. The presence of the remains of marine resources in a terrestrial environment suggests cultural activity. The relative abundance of different fauna may represent patterns of exploitation, and thus patterns of subsistence and settlement. Differences in the diversity of fauna may represent differences in site function.

Skeletal Element, Side, Portion, and Age: Identification as to the skeletal element, the side (right or left), and portion (proximal or distal) of the element, and the age of the individual represented was made whenever possible. Identification of skeletal element, side, and portion was based on the analyst's previous experience and the use of illustrated reference manuals (Olsen 1964, 1968, 1979; Gilbert 1980, 1981), and the comparative collection. Evaluation of age was based on the fusing of epiphyses and sutures; immature individuals were characterized by incomplete fusion.

The purpose of evaluating these various skeletal details was to facilitate the testing of hypotheses concerning prehistoric exploitation strategies and natural depositional processes. Patterning in the distribution of body parts may represent butchering strategies. An abundance of complete skeletons may represents deposition by natural death.

Recording: All information was recorded directly on to FORTRAN coding sheets at the time of analysis.

Estimates of Excavation Volumes: It is important to consider differences in the volume of excavation when comparing absolute counts of bone among sites. To facilitate this, a measure of density, the average bone count per cubic meter of excavation, has been given (see Table 9-71). Due to the variety of field techniques employed and the typically loose, sandy nature of the deposits, an exact measure of excavation volume per site could not be made. The method by which volumes were estimated is described below.

Excavation at most sites involved a combination of controlled units (e.g. 1.0 x 1.0 m units) and STPs (shovel test pits). The volume of controlled units was estimated by multiplying length by width by depth; this is standard archaeological practice. It should be kept in mind that side-walls cut into loose sand tend to collapse. The volumes calculated for the controlled units should be considered approximations. The volumes of STPs are more variable since their surface dimensions (length and width) are not standardized. An estimate of average STP volume in dune sand was made by averaging the values of 21 STPs of measured volume. These values were taken from the fieldnotes of a testing program carried out by UCSB-OPA in the San Antonio Terrace area in 1980 (Haley and Serena 1980). During the course of this program, the volume of sand excavated from each STP was measured in 5-gallon buckets prior to screening, and the depths of each STP were recorded. An average of 4.3 buckets or 21.5 gallons of sand was excavated from STPs of 100 cm depth. This is equivalent to 0.0823 m^3.

Table 9-71. Excavation Volumes per Site.

Site	STP Volumes (m^3)	Unit Volume (m^3)	Total Volume (m^3)
SBa-704	0.21	-----	0.21
SBa-706	5.60	11.60	17.20
SBa-980	0.98	2.00	2.98
SBa-998	6.86	1.40	8.26
SBa-1036	2.45	21.50	23.95
SBa-1037	0.25	-----	0.25
SBa-1038	1.51	2.80	4.31
SBa-1052	0.16	0.70	0.86
SBa-1070	1.14	1.20	2.34
SBa-1070E	0.13	3.00*	3.13
SBa-1155	7.51	2.00**	9.51
SBa-1170	0.82	4.00	4.82
SBa-1174	0.10	6.60**	6.70
SBa-1177	0.85	32.70	33.55
SBa-1179	3.39	17.00**	20.39
SBa-1180S	0.66	2.20	2.86
SBa-1193	24.81	43.10	67.91
SBa-1682	3.46	-----	3.46
SBa-1683	2.22	-----	2.22
SBa-1718	3.75	2.89	5.84

*0.9 m^3 taken in floats and column samples not included in faunal analysis.
**Trench not included.

The total STP volume per site was estimated by multiplying this average volume by the number of STPs and their depths. The volume represented by controlled units and the volume represented by STPs were combined to yield an estimate of total excavation volume per site. Table 9-72 lists the separate and combined volumes for each site.

Descriptions of the Faunal Remains by Site

The purpose of this section is to provide a brief description of the vertebrate faunal remains at each site. Generalizations are made about counts and weights of bone, density of bone per volume of excavation, taxonomic categories represented, burned bone and butchering marks, and fragment size. These generalizations are comparative in nature. The absolute values and percentages from which these generalizations are derived may be found in Table 9-73 through 9-77.

Table 9-72. Taxons Represented Per Site.

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Microtus sp.					+								+				+			
Peromyscus sp.					+						+		+							
Dipodomys sp.											+				+					
Neotoma sp.		+																		
Thomomys bottae		+			+						+		+		+					
Spermophilus beecheyi		+													+					
Rodent, undifferentiated		+	+	+	+		+	+	+	+	+	+	+	+	+		+			+
Sylvilagus sp.	+	+	+	+	+		+	+			+	+	+	+	+		+			+
Lepus californicus		+	+		+								+	+			+			+
Lagomorph, undifferentiated														+			+			
Small mammal, undifferentiated		+	+	+	+			+	+				+							+
Fish		+							+				+		+					
Reptile					+	+	+						+		+		+			
Bird		+	+	+											+					
Small animal, undifferentiated		+	+	+	+	+	+	+	+	+	+		+						+	+
Small/medium mammal, undifferentiated		+			+															

Table 9-72. Taxons Represented Per Site (Continued).

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Canis sp.		+																		
Lynx rufus													+							
Medium mammal, undifferentiated		+											+							
Odocoileus hemionus		+							+				+		+					
Ovis/Capra													+							
Medium ungulate, undifferentiated		+		+	+								+							
Medium/large mammal undifferentiated		+			+	+							+							+
Sus scrofa													+							
Bos taurus					+								+			+				
Large ungulate, undifferentiated													+							
Sea mammal													+							
Large mammal, undifferentiated		+			+				+		+		+	+						+

Table 9-73. Distribution of Taxons Per Site: By Bone Weight.

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Microtus sp.					.04 <1%								.47 <1%				.08 4%			
Peromyscus sp.					.08 <1%						.01 <1%		.10 <1%							
Dipodomys sp.											.05 '1%				.12 <1%					
Neotoma sp.		.08 <1%																		
Thomomys bottae		1.45 1%			2.66 7%						.54 6%		2.52 <1%		.40 1%					
Spermophilus beecheyi		.46 <1%													1.46 3%					
Rodent, undifferentiated		2.68 2%	.15 4%	.09 2%	.58 1%	.18 22%		.06 19%	.02 1%	.01 11%	.39 5%	.08 8%	1.11 <1%	.34 9%	.93 2%		.48 25%			.01 <1%
Sylvilagus sp.	.23 92%	4.06 3%	.08 2%	.31 8%	.47 1%	.34 41%		.10 31%			.07 1%	.93 92%	.57 <1%	.74 19%	.74 2%		.45 24%			.21 5%
Lepus californicus		5.98 5%	1.28 33%		.06 <1%								.95 <1%	.40 10%			.11 6%			.36 9%
Lagomorph, undifferentiated														.11 3%			.01 <1%			
Small mammal, undifferentiated		3.45 3%	.44 11%	.04 1%	.27 1%			.05 16%	.04 2%				.35 <1%							.25 6%
Fish		4.03 3%							.81 31%				.11 <1%		2.23 5%					
Reptile					.05 1%	.28 26%	.11 13%						.05 <1%		.60 1%		.03 2%			
Bird		3.52 3%	.11 3%	.22 5%									12.05 1%		.22 <1%					
Small animal, undifferentiated		16.71 13%	.11 3%	.07 2%	.18 <1%	.04 4%	.05 6%	.09 28%	.01 1%	.05 56%	.11 1%		.19 <1%						.30 86%	1.63 40%
Small/medium mammal, undifferentiated		1.82 1%			.12 <1%															

Table 9-73. Distribution of Taxons Per Site: By Bone Weight (Continued).

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Canis sp.		1.69 1%																		
Lynx rufus													15.79 1%							
Medium mammal, undifferentiated		2.35 2%																		
Odocoileus hemionus		9.60 8%							.54 21%				32.83 2%		36.33 74%					
Ovis/Capra													107.34 6%							
Medium ungulate, undifferentiated		5.91 5%		3.03 74%	.60 2%	.44 41%							178.75 10%							
Medium/large mammal undifferentiated		10.02 8%			.58 1%								38.72 2%							.55 14%
Sus scrofa													57.49 3%							
Bos taurus					31.12 78%								138.88 8%			116.78 100%				
Large ungulate, undifferentiated													681.68 38%							
Sea mammal undifferentiated													17.40 1%							
Large mammal,		26.62 21%			.29 1%				.67 26%		6.77 81%		458.07 26%	1.70 44%						.17 4%
Total Identifiable	.23 92%	100.44 81%	2.17 56%	3.76 92%	37.34 94%	.76 71%	.68 82%	.30 94%	2.09 80%	.06 67%	7.94 95%	1.01 100%	745.41 98%	3.29 85%	43.03 88%	116.78 100%	1.18 62%	-- --	.30 86%	3.18 79%
Unidentifiable	.02 8%	24.16 19%	1.72 4%	.33 8%	2.36 6%	.31 29%	.15 18%	.02 6%	.52 20%	.03 33%	.40 5%	-- --	26.76 2%	.59 15%	5.86 12%	-- --	.73 38%	.05 100%	.05 14%	.85 21%
Total Bone	.25 100%	124.60 100%	3.89 100%	4.09 100%	39.70 100%	1.07 100%	.83 100%	.32 100%	2.61 100%	.09 100%	8.34 100%	1.01 100%	772.17 100%	3.88 100%	48.89 100%	16.78 100%	1.91 100%	.05 100%	.35 100%	4.03 100%

Table 9-74. Distribution of Taxons Per Site: By Bone Count.

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Microtus sp.					1 <1%								11 1%				3 4%			
Peromyscus sp.					7 4%						1 2%		3 <1%							
Dipodomys sp.											2 3%				3 1%					
Neotoma sp.		3 <1%											5 1%		2 <1%					
Thomomys bottae		8 1%			15 8%						6 10%				5 1%					
Spermophilus beecheyi		1 <1%											58 7%	4 15%	41 7%		35 42%			1 <1%
Rodent, undifferentiated		81 6%	5 6%	3 10%	18 10%		5 38%	4 29%	1 3%	1 17%	21 33%	1 33%	8 1%	4 15%	11 2%		4 5%			5 4%
Sylvilagus sp.	1 50%	32 2%	1 1%	4 13%	2 1%		1 8%	1 7%			2 3%	2 67%	4 <1%	1 4%			1 1%			5 4%
Lepus californicus		22 2%	3 4%		1 <1%									2 7%			1 1%			
Lagomorph, undifferentiated													2 <1%							3 2%
Small mammal, undifferentiated		54 4%	11 14%	2 7%	7 4%			3 21%	1 3%				1 <1%		34 6%					
Fish		44 3%							8 26%				2 <1%		21 4%		3 4%			
Reptile					5 3%	7 64%	2 15%						12 1%		2 <1%					
Bird		5 <1%	1 1%	1 3%									2 <1%						3 38%	45 34%
Small animal undifferentiated		346 24%	3 4%	3 10%	5 3%	1 9%	1 8%	4 29%	1 3%	2 33%	4 6%									
Small/medium mammal, undifferentiated		12 1%			1 <1%															
Cannis sp.		1 <1%											2 1%							
Lynx rufus																				

Table 9-74. Distribution of Taxons Per Site: By Bone Count (Continued).

Taxon	SBa-704	SBa-706	SBa-980	SBa-198	SBa-1036	SBa-1037	SBa-1038	SBa-1052	SBa-1070	SBa-1070E	SBa-1155	SBa-1170	SBa-1174	SBa-1177	SBa-1179	SBa-1180S	SBa-1193	SBa-1682	SBa-1683	SBa-1718
Canis sp.		1 <1%																		
Lynx rufus													2 <1%							
Medium mammal, undifferentiated		9 1%																		
Odocoileus hemionus		6 <1%							1 3%				8 1%		5 1%					
Ovis/Capra													5 1%							
Medium ungulate, undifferentiated		3 <1%		1 3%	1 <1%								31 4%							
Medium/large mammal undifferentiated		31 2%			3 2%	1 9%							75 9%							2 2%
Sus scrofa													1 <1%							
Bos taurus					37 20%								7 1%			1 100%				
Large ungulate, undifferentiated													42 5%							
Sea mammal													2 <1%							
Large mammal, undifferentiated		44 3%			3 2%				2 6%		3 5%		317 37%	1 4%						2 2%
Total Identifiable	1 50%	702 48%	24 30%	14 47%	106 57%	9 82%	9 69%	12 86%	14 45%	3 50%	39 62%	3 100%	598 71%	12 45%	124 23%		47 57%		3 38%	63 47%
Unidentifiable	1 50%	747 52%	57 70%	16 53%	80 43%	2 18%	4 31%	2 14%	17 55%	3 50%	24 38%		249 29%	15 55%	426 77%	1 100%	36 43%	4 100%	5 62%	70 53%
Total Bone	2 100%	1449 100%	81 100%	30 100%	186 100%	11 100%	13 100%	14 100%	31 100%	6 100%	63 100%	3 100%	847 100%	27 100%	550 100%	1 100%	83 100%	4 100%	8 100%	133 100%

Table 9-75. Distribution of Fragment Sizes per Site.

Site	Less Than 1/8 Inch	Less Than 1/4 Inch	Less Than 1/2 Inch	Greater Than or Equal to 1/2 Inch	Total
SBa-704	--	1	--	1	2
	--	50%	--	50%	100%
SBa-706	101	775	479	94	1,449
	7%	53%	33%	7%	100%
SBa-980	4	46	26	5	81
	5%	57%	32%	6%	100%
SBa-998	3	15	10	2	30
	10%	50%	33%	7%	100%
SBa-1036	4	113	53	16	186
	2%	61%	29%	9%	100%
SBa-1037	--	8	3	--	11
	--	73%	27%	--	100%
SBa-1038	--	2	10	1	13
	--	15%	77%	8%	100%
SBa-1052	1	3	10	--	14
	7%	21%	71%	--	100%
SBa-1070	1	20	8	2	31
	3%	65%	26%	6%	100%
SBa-1070E	1	5	--	--	6
	17%	83%	--	--	100%
SBa-1155	6	44	9	4	63
	10%	70%	14%	6%	100%
SBa-1170	--	--	--	3	3
	--	--	--	100%	100%
SBa-1174	10	151	281	405	847
	1%	18%	33%	48%	100%
SBa-1177	--	11	13	3	27
	--	41%	48%	11%	100%
SBa-1179	121	323	85	20	549
	22%	59%	16%	4%	100%
SBa-1180S	--	--	--	1	1
	--	--	--	100%	100%
SBa-1193	11	51	21	--	83
	13%	61%	25%	--	100%
SBa-1682	--	3	1	--	4
	--	75%	25%	--	100%
SBa-1683	4	2	2	--	8
	50%	25%	25%	--	100%
SBa-1718	34	64	32	3	133
	26%	48%	24%	2%	100%

Table 9-76. Small, Medium, and Large Fauna; Percentage Distribution per Site by Bone Count.

Site	Small	Medium	Large	Fish & Sea Mammal	Total Identifiable
SBa-704	1	--	--	--	1
	100%	--	--	--	100%
SBa-706	552	22	84	44	702
	79%	3%	12%	6%	100%
SBa-980	24	--	--	--	24
	100%	--	--	--	100%
SBa-998	13	--	1	--	14
	93%	--	7%	--	100%
SBa-1036	61	1	44	--	106
	58%	1%	41%	--	100%
SBa-1037	8	--	1	--	9
	89%	--	11%	--	100%
SBa-1038	9	--	--	--	9
	100%	--	--	--	100%
SBa-1052	12	--	--	--	12
	100%	--	--	--	100%
SBa-1070	3	--	3	8	14
	21%	--	21%	57%	100%
SBa-1070E	3	--	--	--	3
	100%	--	--	--	100%
SBa-1155	36	--	3	--	39
	92%	--	8%	--	100%
SBa-1170	3	--	--	--	3
	100%	--	--	--	100%
SBa-1174	107	2	486	3	598
	18%	1%	81%	1%	100%
SBa-1177	11	--	1	--	12
	92%	--	8%	--	100%
SBa-1179	85	--	5	34	124
	69%	--	4%	27%	100%
SBa-1180S	--	--	1	--	1
	--	--	100%	--	100%
SBa-1193	47	--	--	--	47
	100%	--	--	--	100%
SBa-1682	--	--	--	--	0
SBa-1683	3	--	--	--	3
	100%	--	--	--	100%
SBa-1718	59	--	4	--	63
	94%	--	6%	--	100%

Table 9-77. Distribution of Burned Bone, By Count, Per Taxon Per Site.

Taxon	SBa-706	SBa-980	SBa-998	SBa-1036	SBa-1037	SBa-1052	SBa-1070	SBa-1155	SBa-1174	SBa-1177	SBa-1179	SBa-1193	SBa-1682	SBa-1718
Dipodomys sp.								2						
Rodent, Undifferentiated	16	1						4		1	2			
Sylvilagus sp.	8													1
Lepus californicus	8													1
Small mammal	25	7		1										2
Reptile											2			
Bird		1												
Small animal	112			1										20
Fish	15						3				4			
Small/Medium	6			1										
Medium Mammal	3													
Medium/Large	11			1	1				8					1
Odocoileus hemionus	2								2					
Medium ungulate	1								1					
Large mammal	6			1			1		47					
Unidentifiable	227	19	5	6	2	1	6	13	47	1	72	1	4	32
Total Burned Bone	440	28	5	11	3	1	10	19	105	2	80	1	4	57
Burned/Total Bone	30%	35%	17%	6%	27%	7%	32%	30%	12%	7%	15%	1%	100%	43%

SBa-704: Only two fragments of bone were recovered from a total of five STPs at SBa-704. This represents a bone density of ten fragments per cubic meter of excavation. The total bone weight was 0.25 g.

One of the fragments came from the innominate of a Sylvilagus (brush rabbit or desert cottontail). The other was unidentifiable as to taxon.

Neither fragment was burned, abraded, or demonstrated any butchering marks.

Natural causes are sufficient to explain the presence of vertebrate faunal remains present at SBa-704.

SBa-706: A total of 1,449 fragments of bone weighing a total of 124.60 g was recovered from SBa-706. This represents the highest bone count and the second greatest bone weight from any of the San Antonio Terrace sites discussed in this report. Approximately 17.20 m^3 were excavated, yielding an average density of 84 bone fragments per cubic meter. This represents a density considerably greater than that of most other sites; SBa-1174 is the only other site with a bone density of similar magnitude.

Nine taxonomically distinct categories are represented at the site. These include Spermophilus beecheyi (California ground squirrel), Thomomys bottae Botta's pocket gopher), Neotoma sp. (woodrat), Sylvialagus sp. (brush rabbit and desert cottontail), Lepus californicus (black-tailed jackrabbit), Canis sp. (coyote and dog), Odocoileus hemionus (mule deer), fish, and bird. The majority of the identifiable bone, as measured by count, comes from fauna of jackrabbit size or smaller; this is true of most San Antonio Terrace sites investigated. SBa-706 is one of the few sites to have both deer and fish bone represented. It has the highest absolute count of fish bone of any of the sites. It is also one of the few sites which possesses medium mammal bone.

Thirty percent of the bone from SBa-706 was burned. This includes rodents and lagomorphs as well as deer. Thirty-eight percent of the 440 fragments of burned bone came from small animals.

SBa-706 is one of the few sites which demonstrated any faunal evidence for butchering. Butchering marks were identified on two fragments of medium/large mammal bone, one of Type 1 and one of Type 3.

The pattern of bone fragment size at SBa-706 is typical of most sites investigated. The majority of the fragments, in this case 60 percent, are small enough to pass through a 1/4 inch mesh screen, while most of the remaining fragments would pass through a 1/2 inch mesh screen. Fragments smaller than an 1/8 inch or greater than or equal to a 1/2 inch appear less frequently.

Many lines of evidence contribute to an interpretation of SBa-706 as a site of prehistoric activity. There is both a high absolute count of bone and a high density of bone. A relatively high diversity of fauna are represented (nine distinct taxonomic categories). Fish and deer, resources known to have been exploited by the Chumash (Landberg 1965) are present. There is evidence of butchering, an obviously cultural activity, and 30 percent of the bone collected from the site is burned. No domestic species were identified.

The predominance of small fragments and the predominance of small fauna suggest that the bone may also have redeposited and/or non-cultural components as well.

SBa-980: Eighty-one fragments of bone were recovered from SBa-980, weighing a total of 3.89 g. A total of 2.98 cm^3 was excavated, yielding a density of 27 fragments per cubic meter. This represents a moderate amount of bone relative to other dune sites, in terms of both absolute count and density.

Four taxonomically distinct categories are represented at the site. These include undifferentiated rodent, Sylvilagus sp., Lepus californicus, and bird. All of identifiable bone belongs to fauna of jackrabbit size or smaller. No fish or sea mammal bone and no medium or large mammal bone was recovered.

Thirty-five percent of the bone from SBa-980 was burned. The burned bone included both small mammal and bird. There was no faunal evidence for butchering. The distribution of bone fragment size followed the pattern typical of most of the dune sites. The majority of the bone fragments would pass through 1/4 inch mesh screen.

The faunal remains from SBa-980 appear to have been a product of both natural and cultural deposition. Small local fauna and small fragments predominate, supporting this interpretation. Fish, sea mammal, and deer bone, and butchered bone, whose presence would imply a cultural deposition, are lacking. However, the site does contain a moderate density of bone, a moderate diversity of faunal categories, and a relatively high percentage of burned bone. Although burned bone may result from natural as well as cultural causes, the concentration here of all but one of the burned fragments in a single 1 x 1 m unit, where it was found associated with carbon, fire-altered rock, reddened sand, shell, and hundreds of flakes, argues for an interpretation of cultural burning. The fact that bird, rodent and other small animal bone was burned suggests that such small fauna may have been exploited prehistorically.

SBa-998: A total of 30 fragments of bone, weighing a total of 4.09 g, was recovered from the 8.26 m^3 excavated at SBa-998. This represents an average density of four bone fragments per cubic meter, which is fairly low in comparison to the other dune sites.

Four taxonomically distinct categories are represented at the site. These include undifferentiated rodent, Sylvilagus sp., bird, and medium ungulate. No fish or sea mammal remains were recovered. The majority of the bone came from animals of jackrabbit size or smaller. The medium ungulate category was represented by a single phalange.

Seventeen percent of the bone from SBa-998 was burned. Each of the burned fragments had a maximum dimension of less than a 1/4 inch, weighed less than 0.05 g, and were unidentifiable as to taxon.

There was no faunal evidence for butchering.

The distribution of bone fragment size followed the pattern typical of most of the dune sites. The majority of the bone fragments would pass through 1/4 inch mesh screen.

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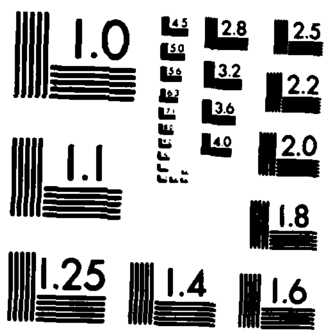

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The faunal evidence at SBa-998 is somewhat ambiguous. The predominance of small fragments and of small local fauna support an interpretation of the deposition of some of the bone as the result of natural processes, including secondary deposition by wind. The medium ungulate bone is large enough and heavy enough to argue for an in situ or primary deposition, but it bears no obvious evidence of cultural activity such as butchering. Although burned bone was recovered and could be interpreted as evidence of cultural activity, the uniformly small size and weight of the fragments argues for an interpretation of redeposition of the burned bone by wind. There is no fish or sea mammal bone to support an interpretation of in situ remains of cultural activity. Overall bone density at the site is low. These combined lines of evidence suggest that the faunal remains at SBa-998 might best be explained as the result of a mix of in situ natural deposition, as well as wind-blown cultural deposition from another source.

SBa-1036: A total of 186 fragments of bone, weighing a total of 39.73 g, was recovered from SBa-1036. Although these absolute values place SBa-1036 among the top five sites in terms of amount of bone recovered, the volume of excavation was also large, yielding the relatively low average density of eight fragments per cubic meter.

Eight taxonomically distinct categories are represented at the site. These include Microtus sp. (voles), Peromyscus sp. (mice), Thomomys bottae (Botta's pocket gopher), Sylvilagus sp. (brush rabbit or desert cottontail), Lepus californicus (blacktailed jackrabbit), reptile (snakes and lizards), medium ungulate (deer, goat, or sheep), and Bos taurus (cow). No fish or sea mammal bone was recovered. Fifty-eight percent of the identifiable bone, by count, is attributable to animals of jackrabbit size or smaller. Forty-one percent comes from large mammals. This relatively high percentage of large mammals is somewhat misleading since most of the count is attributable to a few highly fragmented cow teeth. If the cow teeth fragments are omitted, large mammals represent only 10 percent of the identifiable bone while small mammals represent 88 percent. The category of medium ungulate is represented by a single ungual, or distal phalange (hoof).

Six percent of the bone from SBa-1036 is burned. This burned bone is dispersed, both horizontally and vertically, within the site. Both small and large animals are represented by burned bone. Most of the burned fragments would pass through a 1/4 inch mesh screen; all would pass through a 1/2 inch mesh screen.

No faunal evidence for butchering was observed.

The distribution of bone fragment size followed the pattern typical of most of the other sites. The majority of the bone fragments (in this case 63 percent) would pass through a 1/4 inch mesh screen. An additional 29 percent would pass through a 1/2 inch mesh screen. Only 9 percent of the bone, by count, had a maximum dimension greater than or equal to 1/2 inch.

Beyond the presence of domesticated animals, as represented by Bos taurus, there is no conclusive faunal evidence for cultural activity at SBa-1036. Fish and sea mammal are not represented at the site, and there is

no evidence of butchering marks. The overall density of bone at the site is low and a relatively small percentage of the bone is burned. The high frequency of small fragments and of small local fauna supports an hypothesis of natural deposition.

SBa-1037: Eleven fragments of bone, weighed a total of 1.07 g, were recovered from a total of four STPs at SBa-1037. This represents a relatively high average density of 44 fragments per cubic meter of excavation. This high density is probably of little or no cultural significance since 7 of the 11 fragments came from a single lot and are all reptile vertebrae easily attributable to a single individual.

The vertebrate faunal remains include one fragment of undifferentiated small animal, one fragment of undifferentiated medium/large mammal, and two fragments unidentifiable as to taxon, in addition to the seven reptile vertebrae.

Three of the eleven fragments, or 27 percent of the bone, were greater than 1/4 inch but less than 1/2 inch in maximum dimension. The remainder of the fragments would pass through 1/4 inch mesh screen. None of the bone was larger than 1/2 inch.

The faunal evidence from SBa-1037 suggests a mix of natural and cultural deposition, with an emphasis on the natural. The reptile remains, which are neither burned nor abraded and which were found together, are most likely the result of natural deposition. The three burned fragments, which include the medium/large animal bone and which are all abraded, may be the result of secondary cultural deposition.

SBa-1038: Thirteen fragments of bone, weighing a total of 0.83 g, were recovered from SBa-1038. A total of 4.31 m^3 were excavated, yielding an average density of three fragments of bone per cubic meter. In comparison to the other San Antonio Terrace sites, this represents both a low density and a low absolute count and weight of bone.

Three taxonomically distinct categories were represented. These include undifferentiated rodent, *Sylvilagus* sp., and reptile. All of the identifiable bone is attributable to small, local fauna.

There is no evidence of burning or butchering on the bone.

The pattern of fragment size at SBa-1038 differs somewhat from that typical of most other sites. The majority (77 percent) of the fragments were greater than 1/4 inch and less than 1/2 inch in maximum dimension. The one bone larger than 1/2 inch was a rodent incisor.

Natural causes are sufficient to explain the vertebrate faunal remains recovered from SBa-1038.

SBa-1052: Fourteen fragments of bone, weighing a total of 0.32 g, were recovered from SBa-1052. The total excavated volume was 1.0 m^3, yielding an average density of 14 fragments per cubic meter. In comparison to other sites this represents a low absolute count and weight and a moderately low density of bone.

Two distinct taxonomic categories are represented, undifferentiated rodent and *Sylvilagus* sp. All of the identifiable bone comes from animals of jackrabbit size or smaller.

Only one fragment of bone was burned. This fragment was unidentifiable as to taxon, had a maximum dimension of less than 1/4 inch, and weighed 0.01 g.

There was no faunal evidence for butchering.

The majority (71 percent) of the fragments were slightly larger than those of most of the other sites, falling in the greater than 1/4 inch but less than 1/2 inch category. All of the fragments, however, would pass through 1/2 inch mesh screen; there were no fragments larger than 1/2 inch.

There is no conclusive faunal evidence for cultural activity at SBa-1052. All of the bone is attributable to small, local fauna. The one fragment whose burning might be attributable to cultural activity is small and light enough to have been blown in, and could thus be explained as the result of secondary rather than _in situ_ deposition.

SBa-1070: A total of 31 fragments of bone, weighing a total of 2.61 g, was recovered from SBa-1070. A total of 2.34 m^3 was excavated, yielding an average bone density of 13 fragments per cubic meter. This represents a moderately low density and absolute count and weight of bone, relative to the other sites.

Three taxonomically distinct categories of fauna were identified, undifferentiated rodent, fish, and _Odocoileus hemionus_ (mule deer). SBa-1070 is unique among the San Antonio Terrace sites in that more than 50 percent of the identifiable bone, by count, is fish bone. _Odocoileus hemionus_ is represented by a single fragment of antler time.

Thirty-two percent of the bone recovered from SBa-1070 was burned. Burned bone included fish, undifferentiated large mammal, and bone which was unidentifiable as to taxon.

There was no faunal evidence for butchering.

The patterning of fragment size at SBa-1070 was similar to that at most of the sites. The majority of the fragments, in this case 69 percent, would pass through 1/4 inch mesh screen. A relatively small number of fragments, 6 percent had a maximum dimension greater than or equal to 1/2 inch.

In interpreting SBa-1070 it is important to note that all of the bone came from the upper 60 cm of one 1 x 1 m unit. The field notes and lab records indicate that this unit (Unit 2) was placed in a surface scatter of shell and chipped stone, and that this same 60 cm yielded carbon, shell, asphaltum, hundreds of flakes, a scraper, a biface, and fire-altered rock, along with shrapnel and other metal fragments. Although the nature of the fieldwork which has been done often precludes intra-site spatial analysis, instances such as this one, which do permit recognition of differences in artifact densities across the site area and relationships between surface and subsurface artifact distributions, suggest that attention to such variation might prove valuable in the future.

The vertebrate faunal evidence at SBa-1070 supports an interpretation of _in situ_ prehistoric cultural activity. A high percentage of the identifiable bone came from fish, obviously non-local fauna. All of the bone is concentrated in one small area in association with other artifacts and evidence

of burning. A relatively large percentage of the bone is burned. The bone of large fauna is an abundant as that of small fauna. Deer, a popular game animal prehistorically, is represented.

SBa-1070E: Six fragments of bone, weighing a total of 0.09 g, were recovered from 3.13 m^3 of excavation at SBa-1070E this does not include volumes of column and soil samples (0.9 m^3). This represents an average density of two fragments of bone per cubic meter. In comparison to the other San Antonio Terrace sites, the density and the absolute count and weight of bone from SBa-1070E are low.

Of the six fragments of bone, one is undifferentiated rodent, two are undifferentiated small animal, and the remaining three are unidentifiable as to taxon.

There is no burned or butchered bone, and all fragments have a maximum dimension of less than 1/2 inch.

Natural causes are sufficient to explain the vertebrate faunal remains recovered from SBa-1070E.

SBa-1155: A total of 63 fragments of bone, weighing a total of 8.34 g was recovered from SBa-1155. The volume of excavation was 9.51 m^3, yielding an average density of 7 fragments of bone per cubic meter. This represents a moderate amount of bone in terms of absolute count and weight and a relatively low density of bone.

Five taxonomically distinct categories are represented. These include Peromyscus sp. (mice), Dipodomys sp. (brush rabbit and desert cottontail), and undifferentiated large mammal. Ninety-two percent of the identifiable bone comes from animals less than or equal in size to a jackrabbit. No fish or sea mammal bone was recovered.

Thirty percent of the bone at SBa-1155 was burned. Burned bone included Dipodomys sp. and undifferentiated rodent; most of the burned bone was unidentifiable as to taxon. All but one fragment of burned bone came from a single STP.

SBa-1155 is one of the few sites with butchered bone. Type 3 (mixed or indeterminate) butchering marks were observed on a shaft fragment from an undifferentiated large mammal.

The distribution of fragment size followed the pattern typical of most of the sites. The majority of the fragments, in this case 80 percent, would slip through 1/4 inch mesh screen. An additional 14 percent would pass through 1/2 inch mesh screen. Only 6 percent of the bone had a maximum dimension greater than or equal to 1/2 inch.

The vertebrate faunal remains at SBa-1155 might be best explained as a mix of natural and cultural deposition. The strongest evidence for cultural activity at the site is the presence of large fauna, the relatively high percentage of burned bone, and the presence of butchered bone. However, when other information is considered these lines of evidence become somewhat less persuasive. Butchering marks occur on only one fragment of bone. Large mammals are represented by only three fragments of bone, all of which are found in the upper levels of excavation. Almost all the burned bone

comes from one STP, and the only artifacts associated with it consist of two flakes and some shrapnel. Supporting the hypothesis of natural deposition is the predominance of small, local fauna and small fragment sizes, and the low overall density of bone.

SBa-1170: Only three fragments of bone, weighing a total of 1.01 g, were recovered from the 4.82 m^3 of excavation at SBa-1170. This represents an average density of less than one fragment of bone per cubic meter.

Two of the fragments came from *Sylvilagus* sp., the third from an undifferentiated rodent.

None of the bone was burned, abraded, or butchered.

All three of the fragments had a maximum dimension greater than or equal to 1/2 inch.

Natural causes are sufficient to explain the vertebrate faunal remains recovered from SBa-1170.

SBa-1174: A total of 847 fragments of bone, weighing a total of 1772.17 g, was recovered from SBa-1174. The excavation volume was 6.70 m^3, yielding a very high average density of 126 fragments of bone per cubic meter. SBa-1174 has the greatest weight of bone and the second highest count of any of the sites considered here.

Fourteen taxonomically distinct categories are represented at the site. These include *Microtus* sp. (voles), *Peromyscus* sp. (mice), *Thomomys bottae* (Botta's pocket gopher), *Sylvilagus* sp. (brush rabbit or desert cottontail), *Lepus californicus* (blacktailed jackrabbit), fish, reptile, bird, *Lynx rufus* (bobcat), *Odocoileus hemionus* (mule deer), *Ovis*/*Capra* (sheep or goat), *Sus scrofa* (pig), *Bos taurus* (cow), and sea mammmal. SBa-1174 is remarkable for the diversity of the fauna represented and for the abundance of large fauna (81 percent of the identifiable bone, by count). It is the only site from which sea mammal bone has been recovered.

Twelve percent of the bone from SBa-1174 is burned. All of the burned bone comes from animals of deer/sheep/goat size or larger. Two of these burned bone fragments also show butchering; one of these is identifiable as a deer metatarsal; the butchering was Type 2. Most of the burned bone comes from Lot No. 3298 (the bulldozed area around the large eucalyptus tree just east of the road), from the lower level of Units 7 and 8, which are located northwest of the tree near an adobe feature, and from Unit 2, which is located south of the tree on the opposite side of Grant Road.

SBa-1174 is remarkable for the amount of butchered bone recovered. A total of 40 pieces of butchered bone was found, 11 of Type 1 butchering, and 29 of Type 2 butchering. Type 2 butchering marks are associated with the use of metal tools, while Type 1 butchering marks are associated, although not exclusively, with the use of stone tools. All but 1 of the 40 butchered fragments came from Lot No. 3298, the large bulldozed area around the eucalyptus tree. Lot No. 3298 was collected from bulldozed deposits without horizontal and vertical provenience control; an analysis of the spatial distribution of the different types of butchering marks is thus not possible. Butchering marks were observed on the bones of medium-sized ungulates,

including Ovis/Capra (sheep or goat), and Odocoileus hemionus (mule deer), and on those of large ungulates, including Bos taurus (cow). The details of the distribution of the different types of butchering marks and the taxons and skeletal elements on which they were found are given in Table 9-78.

The pattern of fragment size at SBa-1174 is atypical of the sites discussed here. Nearly half of the fragments (48 percent by count) are greater than or equal to 1/2 inch. This supports an interpretation of the bone as primarily in situ rather than redeposited by wind.

SBa-1174 is unique among the sites discussed here. The vertebrate faunal remains provide strong evidence for historic use of the site. A variety of domesticated animals are represented, including sheep or goat, pig and cow. Much of the bone attributable to large fauna comes from the bulldozed area under the euclalyptus tree, from Units 6, 7, and 8 near the adobe feature to the north of the tree, and from Unit 2 near the cross-roads to the south of the tree. These same three areas account for most of the burned bone. Most of the butchered bone was recovered from the tree area. The fact that almost all of the butchered bone was not burned suggests that the butchered bone represents on-site butchering rather than simple consumption of meat butchered elsewhere. The concentration of bone around the adobe feature and to the south of it suggests that this part of the site may represent a butchering area or a dump.

Non-faunal evidence (e.g,. chipped stone) from SBa-1174 suggests that there is a prehistoric component as well as an historic one. The presence of Type 2 butchering marks on deer bone suggests that historic inhabitants exploited at least some of the same resources as the prehistoric inhabitants. The presence of Type 1 butchering marks may represent the prehistoric inhabitants. The presence of Type 1 butchering marks may represent the prehistoric use of stone tools, but the lack of provenience control on bone fragments with these marks and their association with historic artifacts precludes the identification of a separate prehistoric faunal component.

SBa-1177: A total of 27 fragments of bone, weighing a total of 3.88 g, were recovered from SBa-1177. A total of 33.55 m^3 were excavated, yielding an average density of one bone fragment per cubic meter. In comparison to the other San Antonio Terrace sites, this represents a moderately low count and weight of bone and a very low density.

Four distinct taxonomic categories are represented at SBa-1177. These include undifferentiated rodent, Sylvilagus sp., Lepus californicus, and undifferentiated large mammal. Ninety-two percent of the identifiable bone comes from rodents and lagomorphs. The large mammal category was represented by a single shaft fragment, which was found on the surface of the site.

There are only two burned bone fragments, one from the mandible of an undifferentiated rodent, and the other unidentifiable as to taxon.

There was no faunal evidence for butchering.

Table 9-78. Butchering Marks.

Site	Lot Number	Taxon	Element	Type 1	Type 2	Type 3	Total
SBa-706	3714	Medium/large mammal	rib			x	
	4435	Medium/large mammal		x			
		Totals for Site		1		1	2
SBa-1155	2094	Large mammal	shaft			x	
		Totals for Site				1	1
SBa-1174	3298	*Ovis/Capra*	distal humerus	x			
		Ovis/Capra	distal humerus		x		
		Odocoileus hemionus	metatarsal shaft		x		
		Odocoileus hemionus	proximal metacarpal		x		
		Medium ungulate	proximal radius		x		
		Medium ungulate	vertebra		x		
		Medium ungulate	mandibular condyle		x		
		Medium ungulate	scapula	x			
		Medium ungulate	rib	x			
		Medium/large mammal		x			
		Bos taurus	innominate (acetabul		x		
		Large ungulate	rib		x		
		Large ungulate	rib		x		
		Large ungulate	vertebra		x		
		Large ungulate	vertebra		x		
		Large ungulate	vertebra (immature)		x		
		Large ungulate	astragalus		x		
		Large ungulate	shaft		x		
		Large ungulate	shaft		x		
		Large ungulate	shaft		x		
		Large ungulate	shaft (immature)		x		
		Large ungulate	shaft (immature)		x		
		Large ungulate	articular surface		x		
		Large ungulate			x		
		Large ungulate			x		
		Large ungulate		x			
		Large mammal	vertebra		x		
		Large mammal	vertebra (immature)		x		
		Large mammal	scapula	x			
		Large mammal	scapula	x			
		Large mammal	shaft	x			
		Large mammal			x		
		Large mammal			x		
		Large mammal			x		
		Large mammal			x		
		Large mammal			x		
		Large mammal		x			
		Large mammal		x			
		Large mammal		x			
		Total for lot		11	28		39
	4390	Large mammal			x		1
		Totals for site		11	29		40
Combined Site Totals				12	29	2	43

The fragments at SBa-1177 tend to be somewhat larger than is typical of most of the dune sites, with a few more fragments falling in the greater than 1/4 inch categories than in the less than 1/4 inch ones. The majority of the fragments (in this case 89 percent), however, would pass through 1/2 inch mesh screen.

There is no clear faunal evidence for cultural activity at SBa-1177. Most of the bone is attributable to small, local fauna. The single large mammal bone present at the site was found on the surface, was abraded, and bore the marks of rodent gnawing; its presence does not require a cultural explanation.

It should be noted that bone designated as coming from the vicinity of SBa-1177 was included in the discussion above. This additional bone consisted of two fragments and did not significantly alter any of the generalizations about the site.

SBa-1179: A total of 550 fragments of bone, weighing a total of 48.89 g, was recovered from SBa-1179. A total of 20.39 m^3 was excavated (trench volumes not included), yielding an average density of 27 bone fragments per cubic meter. This represents a relatively high absolute count and weight of bone, and a moderate density.

Eight taxonomically distinct categories of fauna were represented at SBa-1179. These include Dipodomys sp. (woodrats), Thomomys bottae (Botta's pocket gopher), Spermophilus beecheyi (California ground squirrel), Syvilagus sp. (brush rabbit or desert cottontail), fish, reptile, bird, and Odocoileus hemionus (mule deer). The amount of fish bone is notable; 27 percent of the identifiable bone is fish. As is true of most of the dune sites, small terrestrial fauna predominate; at SBa-1179 they represent 69 percent of the identifiable bone. All of the deer bone came from the uppermost level of one unit.

Fifteen percent of the bone was burned. Burned bone included rodent, reptile, and fish, as well as a large number of unidentifiable fragments. Burned fragments occurred in several different units and at a variety of depths. All of the burned fragments had a maximum dimension of less than 1/2 inch and most were less than 1/4 inch in size.

There was no faunal evidence for butchering.

SBa-1179 followed the pattern typical of the other sites in terms of the distribution of fragment sizes. The majority of the fragments, in this case 81 percent, would pass through a 1/4 inch mesh screen. An additional 16 percent would pass through a 1/2 inch mesh screen.

The vertebrate faunal remains at SBA-1179 appear to be largely the product of prehistoric cultural activity. Bone count and weight are high. A relatively high diversity of fauna is represented. Both fish and deer, two resources known to have been exploited ethnographically, are represented; some of the fish bone is burned. The predominance of small fauna and small fragments suggests that the site may include redeposited and/or non-cultural components as well.

SBa-1180S: The vertebrate faunal remains at SBa-1180S consist of one bone, the atlas vertebra of a Bos tauras (cow). This bone was collected from the surface of the site; the 2.86 m^3 of excavation yielded no subsurface bone. There is no evidence of burning or butchering on the bone. Natural processes are sufficient to explain its presence.

SBa-1193: A total of 83 fragments of bone, weighing a total of 1.91 g, was recovered from SBa-1193. A total of 67.91 cm^3 was excavated, yielding an average density of one bone fragment per cubic meter. Although the absolute count of bone is moderate relative to the other dune sites, the weight and density of the bone is low.

Four distinct taxonomic categories are represented. These include Microtus sp., Sylvilagus sp., Lepus californicus, and reptile. All of the identifiable bone is attributable to small, local fauna.

There is one fragment of burned bone. This fragment is unidentifiable as to taxon, weighs 0.01 g, and is small enough to pass through an 1/8 inch mesh screen.

There is no faunal evidence of butchering.

All of the fragments are less than 1/2 inch in size. Seventy-four percent of them would pass through a 1/4 inch mesh screen.

There is no clear faunal evidence for cultural activity at this site. The absence of large fauna, non-local fauna, butchered bone, and large fragments supports an interpretation of deposition by natural processes, including natural deaths of local fauna and redeposition of bone fragments by wind.

SBa-1682: A total of four fragments of bone, weighing a total of 0.15 g, was recovered from the 84 STPs excavated at SBa-1682. This represents an average density of one bone fragment per cubic meter of excavation.

All four fragments were unidentifiable as to taxon. All were burned, and all of them would pass through a 1/2 inch mesh screen. None of them possessed any butchering marks.

There is no clear faunal evidence for in situ cultural activity at SBa-1682. The bone may have been burned as the result of either natural or cultural processes. The uniformly small size of the fragments suggests the possibility of redeposition by wind.

SBa-1683: A total of eight fragments of bone, weighing a total of 0.35 g, was recovered from the 104 STPs excavated at SBa-1683. This represents an average density of 4 bone fragments per cubic meter of excavation.

Three of the eight fragments came from undifferentiated small animals. The remaining five were unidentifiable as to taxon. None of the fragments was burned, and none was butchered. All were small enough to pass through a 1/2 inch mesh screen. None weighed more than 0.02 g.

Natural processes are sufficient to explain the presence of the vertebrate faunal remains at SBa-1683.

SBa-1718: A total of 133 fragments of bone, weighing a total of 4.03 g, was recovered from SBa-1718. A total of 5.84 m³ was excavated, yielding an average density of 23 bone fragments per cubic meter. This represents a moderately high absolute count, but a relatively low weight and density.

Four distinct taxonomic categories were recovered. These included undifferentiated rodent, Sylvilagus sp., Lepus californicus, and undifferentiated large mammal. Ninety-four percent of the identifiable bone belonged to animals of jackrabbit size or smaller.

Forty-three percent of the bone from SBa-1718 is burned. Burned bone includes Syvlilagus sp., Lepus californicus, undifferentiated small animal, and undifferentiated medium/large mammal; the majority of the burned bone is unidentifiable as to taxon.

There is no faunal evidence of butchering.

The distribution of fragment sizes at SBa-1718 follows the pattern typical of most of the other sites. The majority of the fragments, in this case 74 percent, would pass through 1/4 inch mesh screen. An additional 24 percent would pass through 1/2 inch mesh screen.

The interpretation of SBa-1718 is somewhat ambiguous. Small fauna and small fragments predominate, as is typical of most other sites, and their presence can be sufficiently explained as the result of natural processes. There is no obvious evidence of cultural activity such as non-local fauna or butchered bone. However, the percentage of burned bone is unusually high, and the burned bone appears to be distributed across the site and to vary in fragment size from less than 1/8 inch to greater than 1/2 inch. If the bone is considered to be culturally burned, then the prehistoric exploitation of small, local fauna such as Lepus and Sylvilagus is suggested.

Interpretation of the Faunal Evidence

Limitations of the Data: When interpreting the vertebrate faunal evidence from the San Antonio Terrace, it is important to consider the limits of the data. The faunal remains at many of the sites consisted of a very small number of fragments. The subset of bone which was taxonomically identifiable was often smaller still. The sample size per site and per analytic category was thus frequently less than would be ideal for purposes of statistical generalizations. Two of the tests originally proposed rely on patterns of skeletal completeness and the distribution of body parts. The number of identifiable elements for any one taxon at any one site proved too small to be useful for the identification of such patterns. There are, however, discernible differences between the twenty sites from which bone has been recovered; these differences are described below and interpretations are offered.

Depositional Processes: Natural vs. Cultural: Natural and cultural depositional processes combine to form archaeological sites. The identification of the process which resulted in the deposition of any given fragment of bone is an impractical, if not unpracticable, task. Generalizations about the

relative contributions of natural and cultural processes to the formation of a site as a whole are feasible and can be persuasive when multiple lines of evidence support the same interpretation.

Vertebrate faunal remains were recovered from twenty sites on the San Antonio Terrace. These sites may be grouped into three basic sets according to the depositional processes represented.

1. Sites for which natural processes, such as death by natural causes, the activities of rodents and carnivores, wind and brush fires, are sufficient to explain the faunal record. These sites include SBa-704, -1037, -1038, -1052, -1070E, -1170, -1180S, -1193, -1682, -1683.

2. Sites for which the faunal remains may best be explained as a result of a combination of both natural and cultural processes. These sites include SBa-980, -998, -1036, -1155, -1177, and -1718.

3. Sites for which cultural rather than natural depositional processes predominate. These include SBa-706, -1070, -1174, and -1179.

Type 1 sites are characterized by some combination of the following factors: low overall count of bone; the presence of exclusively small fauna; a low faunal diversity; and either the complete absence of burned bone or the presence of burned bone of such small fragment size that redeposition by wind is a possibility.

Type 2 sites are characterized by some combination of the following factors: moderate bone count; the predominance of small fauna; and the predominance of small fragments; in conjunction with characteristics almost surely the product of cultural activity, such as the presence of butchered bone, burned bone in a clearly cultural context, or large game fauna.

Type 3 sites are characterized by the presence of fish and deer bone, a moderate or high bone count, a moderate or high faunal diversity, and in some cases the presence of butchered bone.

The ranking of sites according to patterning of fragment size yielded mixed results. The three sites most distant from the coast and thus most protected from the wind, SBa-704, -1052, and -1174, were among the sites for which fragments of larger size predominated. Within the central portion of the intermediate dunes the significance of the differences which are observable are difficult to ascertain. Two of the sites had only fragments of the largest size; these sites, SBa-1170, and -1180S, also had extremely small total counts of bone (three and one respectively). The remaining two sites for which larger fragments predominated were SBa-1038 and -1177. Both of these sites were closer to the ocean than nearby sites for which small fragments predominated. While the factors responsible for the differences between central intermediate dune sites are not clear, the predominance of fragments less than 1/2 inch in size within the central dune area as a whole is striking.

Subsistence and Settlement Patterns: For the purposes of the discussion of subsistence and settlement patterns, the sites whose faunal remains can be sufficiently explained as the result of natural processes will be omitted. The remaining site include SBa-706, -980, -998, -1036, -1070, -1155, -1174, -1177, -1179, and -1718.

SBa-1174 is unique among the sites discussed here in many ways. To judge from the faunal evidence, it is predominantly an historic site. The abundance of butchered bone and domestic fauna suggest that part of the site may have functioned as a butchering area or a dump, and may have been associated with a homestead or small ranch.

The prehistoric sites may be grouped into three basic types.

SBa-706 is unique among the prehistoric sites. The bone count and bone density are considerably greater at SBa-706 then at any of the other sites. A high diversity of fauna is represented. The presence of fish bone suggests that occupation of the site was of a long enough duration to warrant bringing non-local food resources to the site. The fact that some of the fish bone is burned suggests that fish was cooked and eaten at the site. That bone from small fauna, medium fauna, and large fauna was burned as well suggests that a wide range of hunting activities were being carried on and that the occupation of the site involved either a group of hunters exploiting different resources or a relatively long-term residence or repeated visits to the same area, or some combination of these. Deer, jackrabbits, and cottontails were among the fauna represented in both the burned and unburned bone, suggesting that both small and large fauna were exploited and consumed. Butchering marks were observed on bone which was identified as medium/large mammal and may represent deer. These combined lines of evidence suggest that SBa-706 may have served as a base-camp for the exploitation of dune fauna, and that the hunting strategy was a diversified one.

The remaining prehistoric sites are all unique in some aspect and will be discussed individually. It is suggested, however, that these differences represent variation on a theme and that, with the possible exceptions of SBa-998 and -1177, these sites may have all served similar functions.

SBa-1179 is the second largest of the prehistoric sites in terms of count and density of bone, although it is significantly smaller than SBa-706. A high diversity of fauna is represented in the site and among the burned bone. Fish bone is present and burned, suggesting again that non-local resources were brought in for consumption. Other fauna represented include deer and a variety of small game such as woodrats, pocket-gophers, ground squirrels, cottontails, birds, and reptiles. Rodent and reptile was represented in the burned bone. Once again a diversified exploitation strategy is suggested.

SBa-1036 has a high count of bone but a relatively low density. A high diversity of fauna is represented, including both large and small animals; both large and small animals are burned.

With SBa-980, the discussion shifts to sites with only moderate faunal diversity. Only small fauna are represented at this site; no fish or large mammal bone was recovered. SBa-980 is distinctive, however, for the association of the bone with charcoal, flakes, shell, and fire-altered rock in a hearth-like feature. The burned bone includes bird, rodent, and other small animals, suggesting again that some emphasis was placed on the exploitation of small fauna.

SBa-1070 possessed a hearth-like feature similar to the one at SBa-980. Unlike SBa-980, small fauna did not appear to be the major hunting emphasis. Fish bone, some of it burned, was recovered, suggesting again that these dune sites represent only a part of the total subsistence pattern. Deer bone was also present, and burned bone included large mammal.

SBa-1155 is another site with moderate faunal diversity. Large mammal bone is present but small fauna predominate. Burned bone includes woodrats and other rodents. Butcher marks were identified on large mammal bones. Once again the hunting strategy appears to be diversified and to include both large and small faunal resources.

SBa-1718 has a high count of bone but a moderately low density. The diversity of fauna represented is moderate; small fauna predominate but large mammal bone is present. An unusually high percentage of the bone is burnt (43 percent). The burned bone is dispersed horizontally and vertically throughout the site and includes cottontails, jackrabbits, and other small animals, as well as medium/large mammal bone. A diversified hunting strategy is again suggested.

All of the prehistoric sites described above, with the exception of SBa-706, appear to fit a pattern. It is suggested here that they may represent a series of small, temporary hunting and butchering sites scattered across the intermediate dunes. The hunting strategy appears to have been opportunistic; small fauna were exploited as well as large game such as deer, and the particular small species utilized varied from site to site. The consumption of nonlocal food resources at these sites and the identification of at least one nearby site which is of significantly greater size and density (SBa-706) suggests that these small dune sites may have been part of a larger system.

The last two prehistoric sites to be discussed here are SBa-998 and -1177. Both of these sites appear to fit the pattern outlined above. In both sites the faunal diversity is moderate, small fauna predominate but large fauna are present. In each case the cultural nature of the deposit is somewhat in doubt. All of the burned bone at SBa-998 is small and lightweight and may represent a secondary deposit. At SBa-1177 there are only two fragments of burned bone, and the large mammal bone present has been abraded and gnawed by rodents.

Suggestions for Future Research

Natural and cultural processes combine to form an archaeological site; this is not a revelation, it is a problem. In order to achieve a better understanding of the cultural behavior represented at a site, we need to improve our ability to separate the artifacts of cultural processes from those of natural processes.

The problem is especially tangible in an area like the San Antonio Terrace, where the natural processes are strong and the cultural evidence is weak. The predominance of small, local fauna and small fragment in the faunal collections from most of the sites, even those with very clear evidence of primary cultural deposits, requires some explanation. Simple observation of the natural processes at work today in the dune area suggests that natural deaths, active carnivores, and wind contribute to the distribution, and redistribution, of small fragments of bone. The result is a 'background noise' which does not reflect cultural activity. How can we best filter out such noise and improve our understanding of the archaeological evidence?

A partial solution may lie in the re-orientation of our field techniques. In the past the placement of excavation units has been governed by the needs of mitigation; sampling has been structured without much knowledge of the nature of the deposits being sampled. As our understanding of these sites improves, so may our sampling designs. Many of the dune sites appear to follow a pattern--small concentrations of material are visible on the surface, with low density scatters in between. If greater care were taken during excavation projects to differentiate between such areas within a site, the 'real' site information might lose less of its impact to background noise.

HISTORIC ARTIFACTS

Historic artifacts of various ages were widely scattered within the project area, and they give interesting testimony to the variety of historic activities known or suspected to have occurred on the San Antonio Terrace (see Appendix II). As a class, historic artifacts include all nonaboriginal items collected in the course of field investigations. Although many of these items were undoubtedly discarded within the last decade, systematic collection of all nonaboriginal artifacts was deemed necessary for two reasons. First, it was not always possible to decide in the field whether an item had intrinsic historical significance, that is, whether it was just a few years or several decades old. Second, regardless of age, the frequency of historic artifacts found in aboriginal sites serves as an excellent measure of the degree of disturbance to the site deposits.

All uncatalogued materials were catalogued onto UCSB Archaeological Catalog Forms and assigned to functional classes. Previously catalogued lots were assigned functional classifications and analyzed but were not recatalogued. Analysis of site collections included an assessment of time of deposition as well as possible historic activities on the sites. A summary of this analysis is presented in narrative form in the following section, and occurrences of artifacts by type are included in Table 9-79.

Table 9-79. Distribution of Cataloged Historic Artifacts by Site of Construction Area.

Site or Construction Area Designation	Previously Cataloged	Cataloged by Costello
Fiber Optics/Comm. Line		x
Parking Lot Survey		x
SSF		x
Weather Station		x
SBa-592	x	
SBa-706		x
SBa-980		x
SBa-998		x
SBa-1036	x	
SBa-1037	x	
SBa-1038		x
SBa-1052		x
SBa-1066		x
SBa-1070		x
SBa-1070E		x
SBa-1155		x
SBa-1170	x	
SBa-1173	x	
SBa-1174		x
SBa-1176	x	
SBa-1177	x	
SBa-1179		x
SBa-1180S	x	
SBa-1181	x	
SBa-1193	x(part)	x(part)
SBa-1709H		x
SBa-1718	x	
SBa-1730		

Procedures for Cataloging and Analysis

Most artifacts to be cataloged had generally been/washed and sorted by lot numbers into like material or type. In some cases lots had also been counted and weighed. Artifacts within any lot designation were sorted according to functional type and assigned one catalog number per type. Occasionally material was discarded after cataloging of its potential for further analysis was considered negligible. If discarded, this was recorded in the appropriate column on the Catalog Form.

For each cataloged group, the function, condition, material, fragment type, color, quantity, weight (in grams), and original lot number were recorded. Excavation data, including unit and level designations, were available only for site SBa-1174. Other excavation information such as screen type, feature designations, and excavation data were not available and were therefore not included on the catalog forms. Artifacts were marked with identification and boxed for curation according to the specifications of the UCSB Department of Anthropology.

Analysis was based on a combination of function and date ranges represented by the artifacts. Use of functional categories is not new to archaeologists. The purpose of artifact analysis is cultural reconstruction, and it is more useful to categorize recovered materials according to the associated activities than according to shape of the artifact and the material from which it was made. In many instances, however, the function of an artifact is unknown and most classification systems have, of necessity, been based on material in order to make at least gross comparisons both within a site and between sites.

Historic sites researchers have a greater familiarity with the cultural context of the recovered artifacts. Stanley South (1977, 1978) developed a functional classification for artifacts from historic sites of the southeast U.S. which stimulated renewed interest in this approach. Using South's system as a base, Roderick Sprague (1981) recently published an outline of the classification system used by his students for historic sites in the northwest United States.

The functional classification system utilized in this report was developed by Julia Costello and is incorporated into the cataloging system at University of California, Santa Barbara (Table 9-80). The system is deeply indebted to South's pioneering work and was rigorously field tested and revised during work on the New Melones Lake Project from 1978 to 1980. Final changes were made in consultation with the archaeological staff of the UCSB Department of Anthropology.

Artifacts are first assigned to a general functional category (Group) and then are identified more specifically within these Groups through assignment of appropriate Class and Subclass designations. Artifacts are identified to whatever level of specificity possible. An "unidentified" category is available at every level of identification. The resulting totals of artifact occurrence provide statistics on general cultural categories (Kitchen, Architecture,) at the Group level, and on specific areas within these (table service, cans; round nails, window glass). The system can be used on all historic sites in the United States through and including the modern period.

Summaries of historic materials are presented in Table 9-81, and are specific to the Group and Class levels. Identifications of Subclass are mentioned in the analysis of specific sites if pertinent to the interpretation of cultural activities. The relative occurrence of artifacts by Group has been tabulated by both number and weight. The use of both weight and numbers allows readers to use their own judgement in analyzing the results and makes the collection comparable to those from other sites where only one calculation method was used.

Table 9-80. Functional Groups and Classes Used in Cataloging and Analysis.

Group	Class Examples
Kitchen	Table Service, Social Drinking, Bottles and Jars, Cans, Flatware, Kitchenware, Food, Food Packaging
Architecture	Window Glass, Nails, Hardware, Plumbing, Electrical, Construction Material, Fencing, Roofing, Flooring, Paint
Interior Furnishings	Lighting, Heating, Furniture, Window Treatment, Decorative, Maintenance/Cleaning
Clothing	Buckles/Clips, Buttons, Footwear/Maintenance, Garment, Decorations/Fasteners, Manufacture, Maintenance
Arms	Ball/Shot, Bullets, Handguns, Rifles/Shotguns, Knives, Casings Only, Shrapnel
Personal	Smoking and Tobacco, Coins/Tokens, Watches and Clocks, Suitcases/Trunks/Bags, Hair Accessories, Teeth Accessories, Shaving Accessories, Cosmetics/Perfume, Bath, Hygiene/Medicinal, Jewelry, Eyeglasses/Optics, Miscellaneous
Transportation	Horse Accessories, Wagon/Buggy/Carriage, Bicycle Parts, Railroad Parts, Automobile/Motorcycle, Boats
Shop Industrial	Engine/Machinery Parts, Electric, Mechanic/Shop, Masonry Tools, Blacksmith Tools, Gardening Tools, Carpentry Tools
Entertainment	Musical Instruments, Adult Games, Toys/Child Games, Sport Equipment
Communication	Written/Graphic, Electronic

Table 9-81. *Historic Artifact Occurrence By Site.*

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
FiberOptics Communication Line						
Unknown			6	2	54.2	17
Kitchen			58	20	32.5	10
Table Service	1	.4				
Bottles and Jars	57	32.3				
Architecture			86	30	148.0	48
Window Glass	11	45.1				
Round Nails	70	86.9				
Hardware	3	13.8				
Fencing	1	4.1				
Paint	1	t*				
Interior Furnishings						
Lamp Chimney			4	2	.1	t
Arms			131	45	60.7	22
Casings	1	12.6				
Shrapnel	130	48.1				
Shop/Industrial						
Wire			3	1	10.7	3
Personal			2	t	3.8	t
Cosmetics	1	.1				
Penny	1	3.4				
TOTALS			290	100	310.0	100
Parking Lot Survey						
Arms						
Shrapnel			1	100	14.7	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SSF						
Unidentified			22	4	6.5	7
Brass	1	5.2				
Copper	7	.4				
Wood	4	.1				
White Glass	6	.4				
Aluminum	4	.4				
Architecture						
Bolt/Nail			2	t	9.9	10
Arms			224	34	63.7	67
Shrapnel	223	55.1				
Bullet	1	8.6				
Shop/Industrial						
Insulation			405	62	14.8	16
TOTALS			653	100	94.9	100
Weather Station						
Shop/Industrial						
Unidentified Aluminum			1	100	4.2	100
SBa-592						
Shop/Industrial						
Unidentified Aluminum			1	100	4.5	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-706						
Unidentified			6	1	7.2	1
Brass	3	4.6				
Green Tape	1	.1				
Aluminum	2	2.5				
Kitchen						
Bottles and Jars			38	5	36.8	4
Interior Furnishings						
Mirror	/		2	t	.2	t
Arms			618	88	898.1	90
Shrapnel	603	363.2				
Bullet	8	63.9				
Casings	6	43.9				
Personal						
Tooth Comb			1	t	.2	t
Architecture			4	1	27.2	3
Window Glass	1	2.9				
Hardware	2	2.8				
Wall Board	1	21.5				
Transportation						
Windshield Glass			32	5	7.4	1
Shop/Industrial						
Unidentified Iron			1	t	16.2	2
TOTALS			702	100	993.3	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-980						
Unidentified						
Aluminum			1	4	.2	1
Architecture						
Nail			1	4	2.0	12
Arms						
Shrapnel			25	92	14.4	87
TOTALS			27	100	16.6	100
SBa-998						
Unidentified						
Iron			73	45	28.9	14
Architecture						
Round Nails			17	11	4.7	2
Transportation						
Oil Can			70	44	108.5	84
TOTALS			160	100	214.1	100
SBa-1036						
Unidentified						
Metal, Plastic, Cloth			21	1	31.0	2
Kitchen						
Bottles/Jars	127	112.5				
"Sanitary" Cans	7	5.6				
Styrofoam	10	.4				
Aluminum Foil	1	.1				

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1036 (Continued)						
Architecture			65	5	122.6	8
Window Glass	5	2.9				
Round Nails	24	10.0				
Hardware	11	66.9				
Plumbing	7	17.4				
Brick	16	20.1				
Barbed Wire	2	9.3				
Interior Furnishings						
Mirror			3	t	.2	t
Personal			27	2	28.0	2
Smoking	26	3.8				
Wrist Watch	1	24.2				
Arms			1176	82	488.7	30
Shrapnel	1170	482.7				
Cartridges	3	4.8				
Bullet	3	1.2				
Industrial/Shop						
Large Bolt			1	t	160.7	10
Transportation						
Railroad Spike			3	t	666.7	41
Entertainment						
Skeet Bird			2	t	3.8	t
TOTALS			1443	100	1620.3	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1037						
Arms			4	100	6.0	100
Shrapnel	3	5.8				
Lead Shot	1	.2				
SBa-1038						
Architecture						
Round Nail			1	100	.4	100
SBa-1052						
Kitchen						
Tin Can			12	100	4.6	100
SBa-1066						
Kitchen						
Bottles/Jars			5	100	1.3	100
SBa-1070						
Unidentified						
Brass			1	2	5.1	3
Arms			59	95	94.3	55
Shrapnel	58	94.2				
Shot	1	.1				
Architecture						
Metal Rings			2	3	72.1	42
TOTALS			62	100	171.5	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
Sba-1070E						
Unidentified			4	3	9.7	15
Brass	2	8.2				
Rubber	1	1.3				
Aluminum Drop	1	.1				
Arms			22	24	55.4	82
Shrapnel	21	55.3				
Shot	1	.1				
Shop/Industrial						
Metal Insulation			66	73	2.2	3
TOTALS			92	100	67.3	100
SBa-1155						
Unidentified						
Metal, Glass			4	1	1.2	1
Arms						
Shrapnel			312	99	197.0	99
TOTALS			316	100	198.2	100
SBa-1170						
Unidentified						
Iron Cap			2	9	49.6	60
Arms			18	82	32.3	39
Shrapnel	17	22.3				
Bullet	1	10.0				
Architecture						
Plaster			2	9	.4	1
TOTALS			22	100	82.3	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1173						
Unidentifed			1	3	8.2	2
Arms			35	97	537.2	98
Shrapnel	32	508.3				
Bullet	3	28.9				
TOTALS			36	100	545.4	100
SBa-1174 - Lot No. 3298						
Unidentified			13	2	59.3	2
Plastic	1	1.6				
Melted Glass	4	20.6				
Leather	8	37.1				
Kitchen			384	58	1417.9	42
Bottle/Jar	286	858.2				
Tumbler	1	9.6				
Table Service	87	447.2				
Cooking	3	96.2				
Bone	2	.9				
"Sanitary" Cans	5	4.8				
Architecture			176	26	380.9	11
Window Glass	108	132.0				
Nails	44	71.4				
Barbed Wire	1	84.8				
Paint Can	16	29.4				
Wood	1	29.2				
Hardware	6	34.1				

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1174 - Lot No. 3298 (Continued)						
Interior Furnishings			17	3	294.4	9
Kerosene Lamp	15	20.8				
Wood Stove	2	273.6				
Clothing						
Button			3	t	1.9	t
Arms			14	2	141.0	4
Casings	13	132.5				
Shrapnel	1	8.5				
Transportation			5	1	930.3	27
Railroad Spike	1	65.0				
Buggy/Cart	4	865.3				
Personal			54	8	162.1	5
Coins - 1941	1	3.1				
Medicine	49	141.6				
Cosmetic	2	7.4				
Clay Pipe	2	.2				
Harmonica	1	9.8				
TOTALS			666	100	3387.8	100
SBa-1174						
Unidentified			940	43	587.5	6
Metal	860	545.8				
Tar	61	32.8				
Plastic	6	.5				
Rubber	2	.4				
Leather	11	8.0				

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1174 (Continued)						
Kitchen			587	27	2391.8	23
Table Service	39	369.5				
Tumbler	1	54.0				
Bottles/Jars	373	1800.5				
"Sanitary" Cans	174	167.8				
Architecture			512	23	1164.5	11
Window Glass						
Nails	348	87.4				
Hardware	87	243.8				
Wood	50	11.6				
Plumbing	1	13.9				
Interior Furnishings		12	1		1223.3	12
Kerosene Lamp	5	2.1				
Wood Stove	5	216.3				
Bed Frame	1	1000.0				
Coal-Heating	1	4.9				
Clothing			24	1	280.4	3
Eyelet	3	.4				
Buttons	6	7.7				
Shoe/Boot	15	272.3				
Arms			33	1	376.2	4
Personal						
Glass bead			1	t	.1	t
Shop/Industrial			88	4	4265.5	41
Miscellaneous Machinery	38	3662.2				
Wire	49	47.2				
Plow Blade	1	8.5				

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1174 (Continued)						
Entertainment						
Child's Toys			4	t	8.5	t
TOTALS			2201	100	10,297.8	100
SBa-1176						
Unidentified			2	67	33.7	77
Iron Cap	1	33.6				
String	1	.1				
Arms						
Bullet			1	33	.8	23
TOTALS			3	100	43.5	100
SBa-1177						
Arms			77	100	282.9	100
Shrapnel	75	273.7				
Brass	2	9.2				
SBa-1179						
Unidentified						
Aluminum Strips			4	13	.4	2
Arms			26	87	24.4	98
Shrapnel	25	14.4				
Bullet	1	10.0				
TOTALS			30	100	24.8	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1180S						
Unidentified						
Aluminum			1	100	1.0	100
SBa-1181						
Arms						
Shrapnel			2	100	11.6	100
SBa-1193						
Unidentified			4	4	2.5	1
Metal	2	1.1				
Plastic	1	.3				
Cork	1	1.1				
Architecture						
Paint			2	2	.1	t
Personal						
Smoking			2	2	.3	t
Arms			89	89	337.0	78
Shrapnel	88	328.8				
Shotgun Cartrage	1	8.2				
Shop/Industrial			3	3	89.0	21
Cable Clamp	1	68.6				
Electric Parts	2	20.4				
TOTALS			100	100	429.9	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1709H						
Kitchen			4	2	151.7	1
Enamel Pot	1	2.8				
Bottle/Jar	2	148.9				
Clothing						
Shell Button			1	t	.5	t
Arms						
Shrapnel			201	81	16.7	t
Personal						
Medicine			1	t	5.3	t
Transportation						
Railroad Spike & Plate			38	16	16,290.5	91
Shop/Industrial						
Bolt and Plastic			3	1	1,444.2	8
TOTALS			248	100	17,908.9	100
SBa-1718						
Unidentified						
Aluminum			2	50	2.4	8
Architecture						
Plaster			1	25	.2	1
Arms						
Shrapnel			1	25	25.6	91
TOTALS			4	100	28.2	100

t = trace

Table 9-81. Historic Artifact Occurrence By Site (Continued).

Site or Construction Area (Group /Class)	Class No.	Class Wt. (gr)	Total Group No.	Percent	Total Group Wt. (gr)	Percent
SBa-1730						
Architecture						
Chain Link			1	5	4.1	3
Arms						
Shrapnel			18	95	144.4	97
TOTALS			19	100	148.5	100

t = trace

Analysis Summary

Most of the historic artifacts from the study area directly relate to the recent military presence in the area or to the early twentieth century railroad. Fragments of shrapnel and cartridges identify training maneuvers, and evidence of "off duty" or leisure activities are also present. Artifacts related to ranching activities were also recovered from some sites. The most extensive historic materials were recovered from SBa-1174, the location of an early adobe. Artifact analysis has identified a resident family with children probably dating the last decades of the nineteenth century. Given the lack of specific historical data on this site, the archaeological investigations were especially significant in identifying this otherwise unknown historic occupation.

Historic Artifact Analysis and Interpretation by Site or Construction Area

Fiber Optics/Communications Line: The highest occurrences of the artifacts were in the categories of Arms and Architecture. The Arms consisted almost exclusively of fragments of shrapnel, an apparently ubiquitous artifact in the study area indicating the general presence of simulated military maneuvers. Architectural items included window glass, round nails, some hardware, and a piece of barbed wire fence. While the architectural artifacts suggest wood-frame structures, the fragment of a white ware plate, bottles and jars, a cosmetic jar fragment, and lamp chimneys imply some domestic occupation. The penny and some of the bottles could have been the result of any recent social gathering around the base.

Given the generalized area of the survey, the collection does little more than suggest the types of historic activities that have been present in the project area.

Parking Lot Survey: One bullet was recovered from this surface collection.

SSF: Most of the items recovered from this construction area were either shrapnel or melted synthetic fabric which appears to have been some type of insulation material. All of these items probably relate to the military activities on the base. It is suspected that the brass fragments are from shrapnel casings, but this has not been confirmed. The few other material items recovered could be the result of a wide variety of events.

Weather Station: One fragment of a small, flat strand of aluminum was recovered. It may be associated with some type of military object as others like it were found occasionally on other sites in the project area.

SBa-592: One fragment of unidentified aluminum came from this site.

SBa-706: About 90 percent of the material recovered from this site was classified in the Arms category and consisted of shrapnel, bullets, and cartridge casings. Some modern bottles and glass, including "Sprite", a comb, a smashed windshield, and mirror fragments (which could have come from a car as well as a house) suggest social drinking and perhaps an accident near the site. Some other items such as a screw and washer and an iron piece were also recovered. The historic materials would be consistent with both on-duty and off-duty military use of the area.

SBa-980: Over 90 percent of the historic artifacts recovered were fragments of shrapnel. The only other items were a shred of aluminum (as mentioned above for the Weather Station), and a nail.

SBa-998: Almost half the artifacts by number, and the bulk by weight, belong to the remains of an oil can. The other greatest proportion of artifacts are unidentifiable metal, most likely either additional can fragments too small to identify or small pieces of shrapnel. Several fragments of round nails were also recovered. Nails usually suggest a wooden structure, although the absence of any other architecturally related artifacts may indicate that used lumber was abandoned near this site.

SBa-1036: In numbers, the Arms category, represented overwhelmingly by shrapnel, comprises 82 percent of the artifacts, and is undoubtedly related to military maneuvers in the area. In addition, other groupings of artifacts suggest the presence of a structure, perhaps a small shelter or cabin. Round nails, as well as other artifacts, identify it as a twentieth century occupation. Glass bottles include modern soda and beer containers including brown, green, white, and/light green colors. Some embossing is present such as modern "NO RETURN" messages and product identification. One lavendar glass medicine bottle base was recovered, which suggests a late nineteenth or early twentieth century date, but it is the only representative of this time period.

The structure evidentally had glass windows and some sort of plumbing. In addition to drinking, remains of cigarettes, cigars, and a skeet bird suggest leisure recreation. Other than the one "sanitary" can fragment, there is no evidence of cooking or eating. The absence of any ceramic vessels particularly reinforces the hypothesis that there was a minimum of domestic activities on the site.

SBa-1037: The only historic artifacts recovered from this site were three fragments of shrapnel and one piece of lead shot.

SBa-1038: One round nail fragment was recovered from this site.

SBa-1052: This site yielded 12 tin can fragments.

SBa-1066: Five fragments of green bottle glass were found here. These are remains of a mid-to-late twentieth century vessel.

SBa-1070: The few items recovered from this site from the historic period reflect military maneuvers in the area. Shrapnel is the largest artifact type by both number and weight. Two metal rings, possibly couplings, were also recovered.

SBa-1070E: Shrapnel and the glassious globs of what appear to be melted insulation constitute the largest artifact categories on this site. The other items (shot and brass fragments) also indicate military activities. One piece of unidentified rubber and a piece of aluminum were also recovered.

SBa-1155: With the exception of some small unidentified fragments of metal and white glass, all the historical artifacts recovered from this site were shrapnel pieces.

SBa-1170: Although shrapnel comprised the majority of the artifacts recovered, a large piece of iron from some type of machinery and a small fragment of plaster suggests that something other than general military activities were taking place around the site.

SBa-1173: With the exception of one small unclassified fragment, the artifacts from the historic period all reflect the military maneuvers in the area.

SBa-1174: Lot No. 3298: These remains were recovered from a large disturbed area around a eucalyptus tree just downhill from the SBa-1174 adobe. As this substantial collection differs in composition from the area of the adobe, it was analyzed separately to aid analysis.

In general, the artifacts indicate a domestic occupation dating to about 1870 to 1900. Over 57 percent of the artifacts (by number) are associated with kitchen-related activities while the second most numerous category is Architecture. Interior Furnishings include wood stove and kerosene lamp parts, while window glass, nails, and hardware are associated with the architecture of the building. Personal items include fragments of medicine bottles, a cosmetic jar, a clay pipe, and a harmonica. The kitchen items were represented primarily by glass jars and bottle fragments as well as remains of ceramic bowls, plates, saucers, teapots, and mixing bowls. Leather fragments, a wooden wheel hub, and a tack buckle might be associated with horse-related transportation.

Bottles and ceramics provided the most reliable dating (See Table 9-82). Items datable by manufacturing technique as well as glass color consistently provide dates ranging from 1860 to 1900, 1870 to 1915, 1850 to 1900, 1815 to 1870, 1800 to 1870, and 1870 to 1920. Kerosene lamps roughly date from 1860 and, in rural areas, are still used. Most of the ceramics are undecorated white wares, typical of the last half of the nineteenth century, although several early transfer print pieces date to the 1840 to 1860 time period. All of the nails that could be identified by shape were square nails, roughly indicating a pre-1900 date.

Modern items on the site are comparatively few and are not incompatible with the known twentieth century use of the general project area. Shrapnel and casings are found commonly on sites in Vandenberg and the railroad spikes regularly occur near remains of the old grade. The 1941 penny could have been dropped at any time since that date.

SBa-1174: Structure: A large proportion of the collection corresponds with the items recovered from the area around the eucalyptus tree (Lot No. 3298). Glass fragments include aqua colored medicine bottle fragments dating from 1850 to 1915 (See Table 9-82). A porcelain Lightning Stopper" dates from 1882 to 1915, and fragments of "black" glass belong to the pre-1870 period. Over half of the ceramics recovered were English white ware bowls, plates, and serving bowls. A few ca. 1840 to 1860 transfer print fragments were also present, as were remains of a brown-glazed teapot. One piece of English porcelain was found, and over 20 percent of the ceramic collection was made up of fragments of heavy crockery vessels. Architectural and Interior Furnishings items corresponding to Lot No. 3298 include square nails and kerosene lamp parts.

Table 9-82. Temporarily Diagnostic Artifacts, SBa-1174, Lot No. 3298.

Artifact Description	Date Range	Number	Weight
White ware soup bowl, red transfer print	1850-1875[a]	1	6.3
White ware, blue transfer print	1850-1875[b]	4	11.4
Case bottle	1850-1860	1	57.0
Aqua bottle	1880-1916[c]	1	40.0
Preserve jar, folded rim, pontle mark	1850-1885[d]	8	25.5
Black glass, three-piece mold	1850-1885[e]	12	45.5
Clay pipe	1850-1880(pres)[f]	1	.2
Amber glass, beer hand finish	1860-1913[g]	1	1.6
Cobalt glass	1850-1900(pres)	26	138.1
Aqua medicine bottle, embossed	1880-1916[h]	48	274.7
White bottle, hand finished, double bead	1870-1913[i]	100	108.6
Milk glass	1880-1920(pres)	1	.1
Kerosene lamp chimney	1860-present[j]	12	3.0
Square nails	1850-1900[k]	34	55.3
Plastic	1940-present	1	1.6
"Sanitary" cans	(1900)1917(pres)[l]	5	4.8
Penny	1941	1	3.1
STRUCTURE			
Scene transfer print	1850-1875[m]	3	1.6
Black glass, lipping tool	1850-1885[n]	1	25.6
Aqua Glass	1880-1916[o]	10	110.4
Square nails	1850-1900[p]	45	59.9
Kerosene lamp chimney	1860-present[q]	4	1.5
"Lighting" stopper	1882-1915[r]	1	4.7
Stoneware Marble	1884-1919[s]	1	4.7
Glass canning jar lids	1882-1920	7	18.1
Round nails	1900-present[t]	103	352.2
Aluminum top can	1959-present[u]	1	1.8

[a] Boger 1971:348
[b] Boger 1971:348
[c] Rock 1980a:16
[d] Bente 1978
[e] Newman 1970:Fig 3
[f] Teagye 1980:117
[g] Newman 1970:16
[h] Rock 1980:16
[i] Newman 1970:Fig 3
[j] Lorraine 1968:44
[k] Nelson 1968
[l] Rock 1980b
[m] Boger 1971:348
[n] Newman 1970:Fig 3
[o] Rock 1980a:16
[p] Nelson 1968
[q] Lorraine 1968:44
[r] Newman 1970:Fig 4
[s] Randall 1971:103
[t] Nelson 1968
[u] Rock 1980b

Other recovered items, however, suggest a later occupation of the site. Square nails comprise only 13 percent of the nails recovered, whereas 30 percent are wire-cut (round) of a wide range of sizes. It is probable that the proportion of round to square nails in the remaining 58 percent unidentified to nail type would be similar to the identified types. Cast iron wood stove parts and the large number of tin can pieces could date any time from the mid-nineteenth century through the twentieth century. Most hardware items are generally associated with the twentieth century. They include a spring hook, staples, galvanized items, and metal parts tags. Copper tubing, rivets and a rail from a metal-frame bed were also recovered.

A number of items of heavy machinery were also recovered from the structure, including gears, large bolts and bolt plates, and several unidentifiable portions of equipment, one of which was embossed with "BRIDGEPORT MASS." Large quantities of metal fragments, wire, and some pieces of metal stripping also suggest non-domestic activities in the area.

Some domestic and personal items were also recovered. Although the boot and shoe remains could date to a relatively recent period, the shell buttons, eyelets, and glass bead suggest an earlier time period. The presence of children on the site is evidenced by a marble and a porcelain saucer and cup from a doll set.

Suggested Interpretation of SBa-1174: The nineteenth and twentieth century artifacts on SBa-1174 differ in their functional attributes and site distributions as well as in their temporal assignments. It is hypothesized, therefore, that there were two historic occupations of the site.

The adobe, by its architectural material, would be identified with the Hispanic (1770 to 1850) period of California. Although not well defined, the walls apparently sat on shallow rock foundations, necessary to prevent perculation of groundwater up into the adobe. However, the complete absence of both Spanish-period ceramics and the distinctive roof tiles of this early period suggest that the site is associated with later decades of statehood and Americanization. By the end of the nineteenth century, cattle ranches and homesteads were being established by immigrants from the east, and second-generation Californians from the Gold Rush were expanding out into less developed areas of the state.

The ceramics recovered reflect a typical table setting of the last several decades of the twentieth century. The predominance of simple, undecorated white wares speaks to a practical and utilitarian household. A taste for more exotic and expensive items is seen in the presence of imported Chinese porcelain bowl fragments and some early transfer printed wares. These 1840 to 1860 decorated plates may have been heirlooms as they are not present in any numbers and suggest an earlier date than the rest of the collection. The occupants were likely of Anglosized or American backgrounds since the types of table wares and the presence of an English teapot are typical of these cultural backgrounds.

Bottles which can be attributed to the nineteenth century period include preserve jars, medicine bottles, carbonated beverages, and wine or spirit containers. The household probably consisted of a family, including a woman and children as there appears to be a feminine influence on domestic items and a child's marble and fragments of a porcelain doll's tea set were recovered.

This late nineteenth century household may have utilized the area downhill from the residence, near the present eucalyptus tree, as a trash disposal area. Almost all of the artifacts and virtually all domestic items from Lot No. 3298 suggest a late nineteenth century date. The complete absence of round nails provides a terminal occupation date of ca. 1900. Historical documentary research has identified a subdivision of the area in the 1880s and 1890s (see Appendix II). The initial occupation of the structure at SBa-1174 may be associated with this development.

Twentieth century materials associated with mechanical and shop-related activities suggest that the abandoned structure was later reoccupied. It appears to have been used for spartan lodgings as well as for storage or a shop facility. Artifact dates indicate an occupation in the second quarter of the twentieth century. Renovations or perhaps additions to the original structure are evidenced by the abundance of round nails in a variety of sizes. The cast iron stove parts, bed frame, and quantities of "sanitary" can fragments identify a habitation site; the notable absence of ceramics and cooking vessels, with the exception of a cast iron pan, implies a camp-type facility. The abundance of mechanical and machine artifacts might indicate special maintenance or shop functions for the site. Cattle ranching might require such a building in remote areas of the property.

<u>SBa-1176</u>: The three artifacts from this site consisted of a bullet, a piece of string, and an unidentified part of iron machinery. This small but diverse collection from the historic period may be the result of an activity taking place on land adjacent to this site.

<u>SBa-1177</u>: About 97 percent of the artifacts recovered were fragments of shrapnel. The brass fragments also found are presumed to be from the shrapnel casing since they are commonly found in association with the iron fragments throughout the project area and have been subjected to heat and forceful tearing.

<u>SBa-1179</u>: Almost all of the artifacts fall into the Arms category and all but one of these, a bullet, are shrapnel. Several small ribbons of aluminum were also recovered. These have appeared in other areas of the project and may have come from some type of insulating material.

<u>SBa-1180S</u>: One fragment of an aluminum object was recovered.

<u>SBa-1181</u>: Two fragments of shrapnel were recovered from this site.

<u>SBa-1193</u>: Although the vast majority of the recovered historical artifacts relate to military activities, the numbers and diversity of the other artifacts suggest other activities in the area. Electrical parts, insulation, and a cable clamp may indicate an industrial/electrical function. The paint chips may reflect the former presence of a structure while the plastic, cork, and cigarette foil represent more generalized activities.

SBa-1709H: The proximity of the abandoned railroad bed to this site is undoubtedly responsible for the occurrence of the railroad spikes and plates, as well as the other large bolts and bolt plates. Other artifacts indicate that some domestic activities were also going on in the area: bottle glass, an enamel pot, a shell button, and medicine vial. Fragments of purple glass would suggest a pre-1920 date, although the medicine vial is post-1925. A reasonable occupation date would be from the 1920s through the mid-twentieth century. Shrapnel was also recovered and indicates a military use of the area after the abandonment of the railroad.

SBa-1718: Fragments of shrapnel, plaster, and aluminum were recovered.

SBa-1730: Shrapnel comprises most of the historical artifacts from this site. One link from a chain fence was also recovered.

SBa-1730: Shrapnel comprises most of the historical artifacts from this site. One link from a chain fence was also recovered.

OTHER ARTIFACT CLASSES

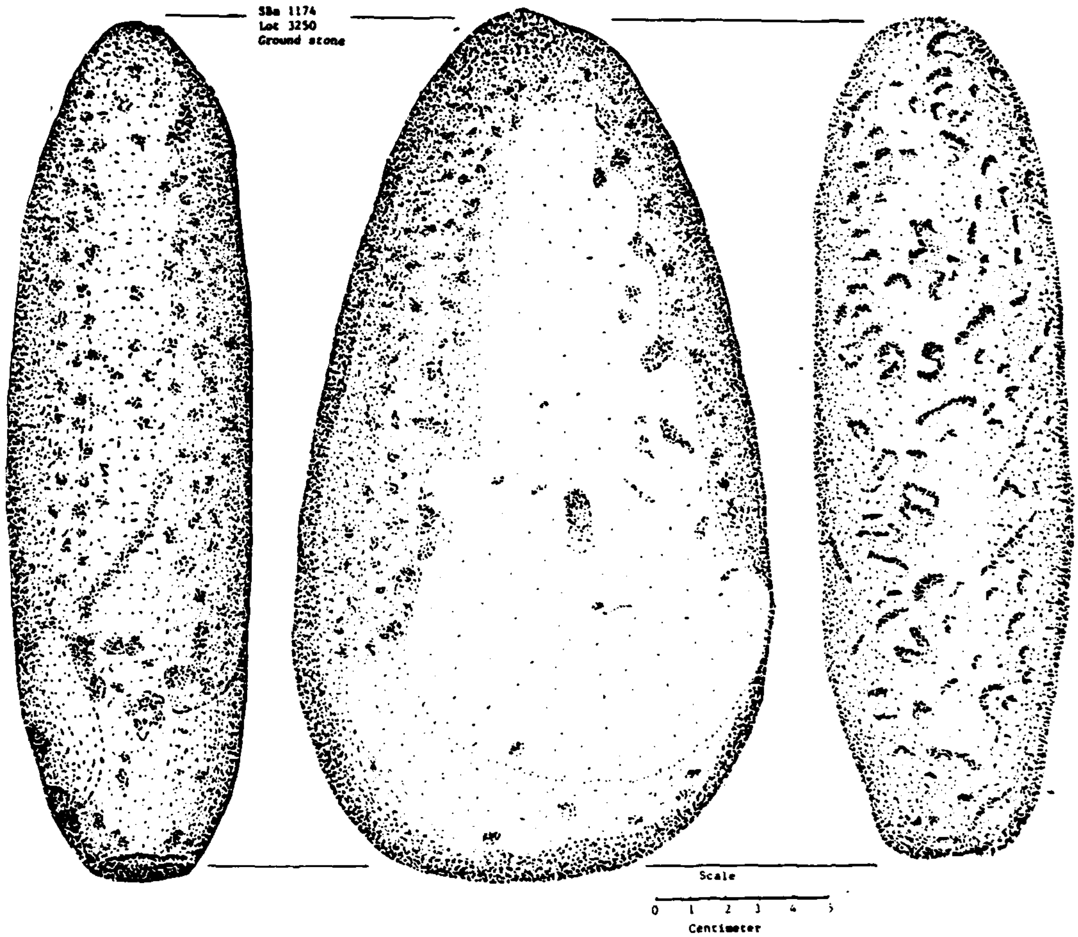
Introduction

Classes of artifacts other than chipped stone are in much lower frequencies in the collections. Only four worked shell objects were encountered (described above under shellfish remains), and worked bone objects include only several pieces of bone showing butchering marks (described above under vertebrate faunal remains). Remaining classes to be described include ground stone artifacts, asphaltum nodules, and fire-affected rock. These are considered in turn below.

Ground Stone Artifacts

Two items of ground stone were encountered, both from SBa-1174. One of these is a large, elongate sandstone cobble slightly shaped by pecking over more than 50 percent of its surface (dimensions: length = 25.4 cm., width = 13.5 cm, thickness = 8.5 cm). There is slight abrasion on one face and on one end, implying use as both a mano and a pestle, although the object does not conform to a conventional morphological category of either manos or pestles. This mano/pestle came from the surface of SBa-1174 near the adobe ruin at this site, but it is assumed to be associated with the prehistoric rather than the historical component of this site (see Figure 9-12).

The other object is a fragment from the body of a Catalina Island steatite cooking olla (dimensions: length = 7.5 cm, width = 5.8 cm, thickness = 2.6 cm) (see Figure 9-12). The convex surface of this curved fragment is covered with a thick layer of carbon, indicating its use over an open fire. This object was recovered from the screening of disturbed deposits around a large eucalyptus tree removed from a location below and south of the adobe ruin. These disturbed deposits contained considerable historic trash associated with the use of the adobe building, and there is the


SBa 1174
Lot 3250
Ground stone
Scale
0 1 2 3 4 5
Centimeter

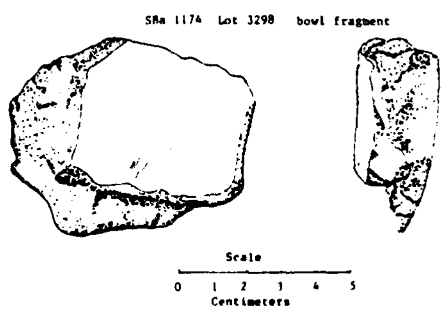

SBa 1174 Lot 3298 bowl fragment
Scale
0 1 2 3 4 5
Centimeters

Figure 9-12.

possibility that the steatite olla from which this fragment came was used by the nineteenth century occupants of the adobe, even though the ultimate origin of the olla is prehistoric. Schumacher (1877:54) indicates that the "Spaniards" of this locale were in the habit of digging up steatite ollas from prehistoric sites and reusing them as cooking vessels in the same manner as they were used prehistorically. Possibly the steatite vessel fragment from Sba-1174 came from such a historically reused vessel.

The thinness of the small fragment is diagnostic of Late Period vessels, although steatite vessels are known to have been used in the Santa Barbara Channel region beginning in phase M4 (A.D. 700-900) of the Middle Period (C. King 1981:149).

Asphaltum Nodules

Asphaltum normally occurs at sites as small, hard nodules with a gritty appearance because of the inclusion of sand. A few larger pieces are relatively pure asphaltum, which may be the form in which it was kept prior to use.

Only four sites, SBa-980, -1070, -1179, and -1565, yielded asphaltum nodules of unquestioned aboriginal origin. SBa-706 probably also contains asphaltum of aboriginal origin, but since much of the asphaltum from this site appears to have come from the adjacent road, along which the excavations took place, the aboriginal and historic asphaltum often cannot be easily differentiated. The occurrence of asphaltum is tabulated by site in Table 9-83, with the omission of that from SBa-706 because of the problem just mentioned. The frequencies per site indicated in Table 9-83 reveal that asphaltum occurs in very sparing quantities at all sites except SBa-1179 (and probably also SBa-706). This implies that asphaltum nodules may also a number of other sites investigated as well, but were missed by the limited amounts of excavation at most sites.

One level of a unit at SBa-980 contained three nodules, all under 1.0 cm in length. SBa-1070 contained a piece approximately 2.5 cm long, apparently a fragment from a larger nodule. Only one small fleck came from SBa-1565. By far the most asphaltum nodules came from SBa-1179, where nearly every level within the cultural deposit yielded small quantities. Only 15 of the 101 lots (i.e., levels) of asphaltum from SBa-1179 weigh more than 1.0 g, and even in these cases the majority of pieces are small, usually only 3 to 5 mm in length. One lot, however, consisted of a 3.7 cm long pebble-shaped nodule of relatively pure asphaltum. A cache-like concentration of asphaltum nodules collected by VTN archaeologists during heavy equipment grading comprises the largest lot--88.0 g in all.

Asphaltum was used by the Chumash and their predecessors as both a fixative and a waterproofing agent. Its use as a fixative was largely in the context of attaching shell beads and ornaments to the surfaces of bone and stone objects, a practice especially common during the latter part of the Middle Period (C. King 1981:60-62). As a waterproofing agent, it was used to caulk plank canoes and to coat the insides of water baskets (Grant 1978).

Table 9-83. Distribution of Asphaltum Pieces.

Site	Number of Lots	Weight in Grams	Comments
SBa-980	1	5.9	3 pieces
SBa-1070	1	7.6	Apparent fragment of patty-like lump
SBa-1179	101	117.27	22 lots approx. 0.01 g each 51 lost approx. 0.02 to 0.1 g 13 lots approx. 0.2 to 0.9 g 11 lots approx. 1.0 to 10.0 g 3 lots approx. 10.0 to 20.0 g 1 lot approx. 88.0 g
SBa-1565	1	0.1	

Since plank canoes were not used by the Chumash living north of Point Conception, and since no objects with bead or ornament applique were encountered in the investigations (nor would be expected), the most likely use of asphaltum was in coating water baskets. In fact, the aboriginal use of asphaltum coated water baskets was reported by the eighteenth century Spanish expeditions which passed through the San Antonio Terrace vicinity (see Appendix I). The asphaltum in the collections occurring as large, relatively pure nodules probably represents its stored form. Surface features consisting of patty-like lumps are known to be present at SBa-706 and -998. The one fragment from SBa-1070 probably came from a lump of this sort. The small pieces at SBa-1179 may have come from the sides of coated water baskets and were introduced into the cultural deposit in the course of the baskets' normal use or perhaps after they were discarded. No conclusive evidence was encountered of the activity of coating water baskets, as described by Craig (1966:210). Tarring pebbles, absent in the collections, would be a clear indicator of this activity.

Fire-altered Rocks

Fire-altered rocks were collected from 16 sites, and their frequencies and weights by material and by site is tabulated in Table 9-84. Fire-altered rocks occur in the collections as angular chunks generally between 1.0 and 5.0 cm in maximum dimension. The few spalls weighing less than 10 g were not included in Table 9-84. At least one surface on each chunk is almost always water-worn cortex which shows darkening or reddening from contact with fire. The fragmentation pattern exhibited by these rocks is the typical result of thermal fracturing. Although only a few of the fire-altered rocks

Table 9-84. Distribution of Fire-Affected Rock.

Site	Material	Quantity	Weight in Grams	Comments
SBa-706	Igneous	35	2495.4	
	Quartzite	2	155.8	
	Sandstone	3	242.5	
	Shale	1	12.0	
	Total	41	2905.7	(3 from STPs, 3 from surface, 6 from trench)
SBa-980	Igneous	3	208.3	
	Quartzite	1	83.7	
	Sandstone	1	58.3	
	Total	5	350.3	
SBa-998	Igneous	1	22.1	
	Quartzite	1	26.7	
	Total	2	48.8	
SBa-1036	Sandstone	2	62.0	
SBa-1070	Igneous	3	224.2	
	Sandstone	2	89.4	
	Total	5	313.6	
SBa-1170	Igneous	1	30.6	
	Quartzite	1	17.4	
	Total	2	48.0	

are complete cobbles, many of the fragments are large enough to indicate their origin from fist-sized cobbles, probably no more than 10 cm in length in most cases. The majority of the rocks, 80.9 percent of the total, were igneous rocks, including basalt and granite of varying coarseness of grain and hardness. Sandstone cobbles, which were normally reddened rather than darkened as a result of contact with fire, comprise 14.2 percent of the total, and quartzite comprises 4.3 percent. One burned Monterey shale tabular rock was also encountered. It would appear that igneous rocks were preferred as heating stones, very likely because of their superior thermal properties. However, purposeful selection cannot be verified at present since the proportions of cobbles of different rock types occurring at possible source locations have not been determined. Likely sources include cobble beaches and coarse alluvial deposits.

The presence of fire-altered rock probably indicates one of two possible procedures for cooking plant foods: roasting pulpy plant parts in pits filled with heated stones and boiling gruel or mush by placing heated stones in baskets full of this commodity.

Chapter 10

SUBSISTENCE-SETTLEMENT SYSTEMS ON THE SAN ANTONIO TERRACE

INTRODUCTION

The main objective of the data analysis has been to reveal something of the subsistence-settlement systems which characterized the prehistoric ecological adaptations to the environment of the San Antonio Terrace and immediately surrounding lands. The different aspects of the analysis presented thus far have resulted in a variety of information on the nature of prehistoric subsistence-settlement systems, and one of the purposes of this chapter will be to bring together into an integrated framework the various inference presented earlier. Of the various analyses, that of the chipped stone collections was able to generate the greatest variety of hypotheses regarding subsistence and settlement, and that analysis will be given particular consideration in developing models of subsistence-settlement systems which take into consideration the other data collected beyond the chipped stone. At the same time, an effort will be made to utilize the data on the nature and distribution of archaeological sites throughout the San Antonio Terrace and the immediate vicinity. The interpretations of these data by Spanne (1974) will be especially useful in this regard.

The research design for the Vandenberg MX Archaeological Project presented in Chapter 2 divided the analysis of subsistence-settlement systems into three basic topics: settlement structure, intrasite variability, and resource procurement and use subsystems. Of the three, most can be said about settlement structure and resource procurement subsystems, while much less can be said about intrasite variability because of the lack of much data bearing on this topic. It is logical to begin the analysis of subsistence-settlement systems by considering first the evidence for resource procurement and use subsystems because the identification is necessary for the definition of settlement types and ultimately settlement structures. In other words, a functional typology of sites and the nature of their spatial organization depends upon knowledge of the kinds of resource procurement and use activities that took place at each site.

RESOURCE PROCUREMENT AND USE

For each resource, five realms of information are relevant to the description of procurement and use:

1. Use or uses to which the resource was put;

2. The procedures for obtaining the resource;

3. The location or locations from which the resource were obtained;

4. The location or locations to which the resource and its byproducts were transported; and

5. The procedures for processing and consuming the resource.

To the maximum extent possible, each of these five topics will be considered for each class of resources known or suspected to have been used by the prehistoric inhabitants of the San Antonio Terrace.

Terrestrial Mammals

Although few remains of terrestrial mammals were obtained during the course of the project, there is abundant evidence that their pursuit was a major activity of the prehistoric people who visited the San Antonio Terrace. In fact, aside from the recent development of MX facilities, hunting of terrestrial mammals has continued to be a dominant activity taking place on the terrace. The analysis of vertebrate faunal remains revealed that the prehistoric inhabitants of the terrace obtained and ate representatives of all mammal species the size of a gopher or larger found in the environment today. The most obvious evidence of methods of capture are the projectile points in the collections, which would have been used to tip darts, spears, and arrows. These weapons were probably used principally for larger game, whereas traps, snares, and throwing sticks would typically have been used for game the size of a jackrabbit or smaller. Although there is no direct evidence of the use of traps and snares, it is possible that some of the stone tools identified by Bamforth as woodworking tools were used in the construction of such devices. Hudson and Blackburn (1982:45-72) have recently inventoried ethnohistoric and ethnographic and archaeological information concerning the use by the Chumash of a wide variety of traps, snares, various stick devices, and nets for the capture of small animals and, in some cases, large animals the size of deer as well. There is good reason for suspecting, therefore, that the inhabitants of the San Antonio Terrace used a much wider variety of hunting devices beyond those for which there is direct evidence.

The relative importance of the different species of terrestrial mammals is difficult to ascertain on the basis of available evidence. The bones of small animals the size of jackrabbits or smaller predominate in the collections, but it must be kept in mind that the meat from one deer is comparable to that from 10 to 15 rabbits or many more numbers of smaller species. Furthermore, as Bamforth discusses in Chapter 9, it is likely that many of the animals killed on the terrace were transported to other locations off the terrace, and this

may be especially true of deer. Regardless of relative importance, it is clear that so far as terrestrial mammals are concerned, "diet breadth" (to use a term popular in evolutionary biology) was quite broad. That is, there is no evidence for specialization on one or a few species.

There are reasons for suspecting that deer may have been a preferred species, even though many smaller mammals were also exploited. First, one deer would provide considerably more meat than one animal of all other species (except bear, for which no evidence of exploitation was encountered), and if search and pursuit time was nearly the same for each species, deer would provide a much greater payoff for a given amount of hunting effort expended. Second, certain habits of deer appear to be relatively predictable, especially of those deer occupying the intermediate dunes. In this habitat, deer frequent the wetlands for a variety of purposes, depending on the amount of wetness. Those which are relatively dry and contain thickets of willow and verdant blankets of grass provide not only browse but also places of refuge. Those wetlands with standing water provide both special browse and drinking water. Deer trails are also relatively distinct in many parts of the dunes. These conditions provide a number of opportunities for ambush and stalking, and search and pursuit time per deer kill may have been relatively low. So far as hunting deer in wetland locations is concerned, a small group of men, perhaps a half dozen, using a strategy of surrounding a wetland and then flushing out the deer contained within, may have increased the chances of a kill such that the net return per individual hunter was more than if each hunted alone.

Despite their likely preference, deer would probably not have been sufficiently abundant to provide all the meat that the local population required for subsistence. Coulombe and Cooper (1976:175) estimate that between 10 and 20 deer per square mile (approximately 4 to 8 km^2) occupy lands covered by all phases of the coastal sage scrub community on the base. Since this community type is the dominant one on the San Antonio Terrace, an intermediate figure of 15 deer per square mile may be used to derive an estimate of 281 deer living within the 18.75 square miles (48.56 km^2) of the terrace. This number would support between 18 and 19 people if two assumptions are made: first, that a maximum of 25 percent of the deer herd could be harvested per year (i.e., a 25 percent sustained annual yield), and second, that deer and other game contributed principally protein to the oboriginal diet in light of the abundance of plant foods also available in the area. The average mule deer living on the base would provide about 4.76 kg of protein and the annual human requirement is about 18.25 kg of protein per year (see Glassow and Wilcoxon 1979 for details in making these assumptions and calculations). At the time of European contact, the Chumash villages of Lospe and Saxpil, just north of the San Antonio Terrace, contained populations of 40 to 60 and 125 to 150 individuals, respectively (see Appendix 1), and if just one of these villages utilized resources from the San Antonio Terrace, the abundance of deer would not have been sufficient. It is little wonder, then, that a wide variety of game animals were sought by the aboriginal populations hunting on the terrace.

Figures on the densities of smaller game animals are not available, but it may be noted that roughly 40 to 60 rabbits would be needed to provide the annual protein needs of one individual, implying that the three species of rabbits available to Vandenberg region populations would also have been under considerable pressure if they were the only animals hunted.

Bamforth argues in Chapter 9 that game killed in the central portion of the terrace, within the intermediate dunes, was butchered near the kill and then transported to residential sites such as SBa-706 on the edge of the terrace or beyond. This would account for the presence of butchering tools at many of the sites of the terrace interior, as well as the low numbers of skeletal parts of the animal parts encountered in these sites. Relatively more extensive butchering of deer than of smaller animals may have taken place at the temporary camps in the intermediate dunes, not only because of their larger size, but also because the meat may have been divided at the camp between individual participants in a kill.

Birds, Reptiles, and Sea Mammals

Other classes of game animals are very poorly represented in the faunal remains from the sites. In fact, at least some of the bird and reptile bone was probably introduced into the sites through natural processes. Nonetheless, a reasonably strong case can be made for the exploitation of birds, although their remains have not been identified to species. The greatest occurrence of bird bones was at sites also containing an abundance of other animals bones (notably SBa-706 and -1179). Species of birds likely to have been exploited include California quail (Lophortyx californica), which would have been trapped or snared (Hudson and Blackburn 1982:65, 71). Coots (Fulica americana) and ruddy ducks (Oxyura jamaicensis) are currently the only two water fowl available year-round in the Vandenberg region (Coulombe and Cooper 1976:133). Coots are especially abundant in the perennial ponds of the terrace. In addition, seasonally present water fowl, specifically mallards (Anas platyrhynchos) and cinnamon teals (Anas cyanoptera), breed in Vandenberg waters (Coulombe and Cooper 1976:181). Chumash are known to have hunted birds with bow and arrow, the arrow having a compound wooden point especially for birds (Hudson and Blackburn 1982:110). Water fowl were hunted specifically through the use of a "duck corral," an enclosure of reeds into which swimming ducks were herded (Hudson and Blackburn 1982:63).

In light of the abundance of both quail and coots on Vandenberg, it is surprising that there is not more evidence of their exploitation. Preservation of bird bone in identifiable form may be one reason for the paucity of evidence. Given the propensity for bone in sites of the project area to break into rather small pieces, it is possible that much of the unidentifiable bone is that of birds. This is only partly the answer, however, because some distinctive parts of bird skeletons should have preserved at least as well as fish bone, which is present in noticeable quantities at several sites. It may be that hunting birds did not yield success rates as high as comparably sized mammals. In other words, diet breadth did not extend to such a point to include much emphasis on birds.

Sea mammals were represented only in the bone assemblage from SBa-1174 and were probably associated with the historic component of that site. The virtual absence of sea mammal bone in the prehistoric sites is especially surprising in light of the presence of fish bone in several of the sites and the abundance of sea mammal bones in excavated coastal sites elsewhere in the Vandenberg region (Glassow et al. 1981). In fact, sea mammal bone occurs in some quantity at an Ynezeno Chumash village about 45 km east of the San Antonio Terrace (P. Walker, personal communication). Preservation of sea mammal bone is probably not the explanation since fish bone is reasonably well preserved. It is also doubtful that sea mammals were simply not exploited along the coastline near the San Antonio Terrace since hawlout spots of California sea lion (Zalophus californianus) and harbor seal (Phoca vitulina) are known to exist at both Point Sal and Purisima Point (Coulombe and Mahrdt 1976:134-135). One possibility is that imported meat included only that which had been processed for preservation (e.g., dried fish) or could last for several days without processing (e.g., shellfish). Sea mammal flesh may not have been locally preserved in this fashion, and therefore the bones of sea mammals did not find their way into San Antonio Terrace sites.

Fish

Marine fish remains were especially abundant at two of the sites investigated, SBa-1070 and -1179, but were also present at two others, SBa-706 and -1174 (probably associated with the historic occupation at the latter site). The considerable abundance of fish remains at some sites and the absence at others implies that under only certain circumstances were marine fish transported to sites away from the coast. The principal reason may have had something to do with the duration of episodes of occupation at the sites. If sites were only for day-use, there may have been little incentive to bring food along, but in cases of longer-term occupation, food was imported in the anticipation that locally available food resources, especially those providing meat (i.e., protein) may not be consistently available through the duration of the stay. This implies that fish was imported into temporary sites of the terrace in some sort of storable form, probably dried, and that the fish was prepared at a site some distance away which served as a residential base. Although the topic of settlement diversity will be discussed at some length further on, it should be mentioned here that SBa-706 and -1070 could have been residential bases at which fish were prepared, while SBa-1179 was likely a site to which prepared fish were imported.

Although the fish remains were not identified to species in the analysis of osseous remains, observations by the principal investigator indicate that most if not all are those of nearshore fishes prevalent along rocky shorelines such as those occurring in the vicinity of Point Sal and Purisima Point. The heavy surf off the sandy beaches between these points was probably not exploited to as great an extent, although surf fishermen do fish this shoreline

today, and a series of relatively smaller sites than at the points are scattered just behind the beach. The use of hook-and-line to obtain fish is reflected in the occurrence of a shell fishhook fragment at SBa-706. While this gear may have been the most prevalent for fishing, the Chumash are known to have used a wide variety of devices (Hudson and Blackburn 1982:149-225).

Shellfish

Shellfish remains occur in the majority of sites investigated, although usually in only trace amounts. Five prehistoric sites contained significantly more shellfish remains than the others: three on the southern edge of the terrace (SBa-706, -980, and -1070) and the other two in the central portion of the intermediate dunes (SBa-1179 and -1718). The variation in the abundances of shellfish remains implies that this food resource may have articulated with aboriginal subsistence in two different ways. For the majority of the sites, where occupation is suspected to have been principally a day's duration, a few shellfish may have been brought along for one meal. Where shellfish remains are more abundant, however, larger amounts of shellfish may have been brought in as a backup food resource which could be kept for several days and used when hunting and collecting in the immediate vicinity of the site was not successful. In either event, shellfish were probably not prepared before transporting them inland beyond perhaps protecting them from direct exposure to the sun.

Serena indicates in Chapter 9 that virtually all species of shellfish represented in the collections come from rocky shorelines, implying that the vicinities of Purisima Point and/or Point Sal were the collection zones. The sandy beach forming the western edge of the San Antonio Terrace was apparently not exploited for such shellfish as pismo clam. No special tools would have been necessary for collection of shellfish beyond some sort of prybar to remove firmly attached species such as abalones. Indeed, an important value of shellfish as a food resource is the ease with which they can be collected and the high degree of predictability of the numbers which can be obtained in a collecting episode. No other meat source has these advantages. On the negative side, however, shellfish beds can be relatively quickly depleted of mature individuals, as pointed out by Serena in Chapter 9, and a considerable number must be collected if they are to provide the same amount of protein available from animal meat. Although data are not available for estimating the carrying capacity of local shellfish beds, it is quite likely that aboriginal exploitation was at its feasible maximum. This seems a reasonable conclusion in light of the relatively high densities of shellfish remains in coastal sites near Purisima Point and the mouth of Shuman Canyon north to Point Sal.

Plant Foods

Evidence of the use of plant foods from San Antonio Terrace sites is scanty and indirect. In an attempt to recover direct evidence of plant foods, flotation procedures to recover carbonized plant remains form soil samples was

applied without success using deposits from several of the sites. However, this does not mean that carbonized remains are not present at these sites; it is possible that soil samples from the denser midden deposits from sites such as SBa-706 and -980 may produce such remains.

Milling implements are another direct indicator of the utilization of plant foods--specifically seeds and acorns. These classes of plant foods were clearly not important to dwellers on the San Antonio Terrace, although it is certainly possible that they could have been imported already in milled form. Only SBa-1174 yielded a milling implement, this being a slightly used mano/pestle. This site and nearby SBa-1052 are adjacent to oak woodlands and grasslands, so it would not be surprising that at least some collection and milling of seeds and acorns took place using these sites as bases. It is also not surprising that collection of seeds and acorns did not take place in the dune-covered areas of the San Antonio Terrace. The coastal sage communities that predominate on the dunelands do not appear to contain plants which yield easily collectable seeds, and oaks are very sporadic in their distribution on the dunes.

The collection of pulpy parts of plants such as the roots and shoots of cattail (<u>Typha latifolia</u> and possibly other species of <u>Typha</u>) is predictable simply on the basis of the ease with which these nutritious plant parts can be gathered and their abundance in the wetter wetlands of the terrace. Direct evidence of their collection is not expected, however, since tools used to collect them would have been either perishable (e.g., digging sticks) or discarded in the wetlands and therefore inaccessible to archaeology. Significantly, the only plant knives identified in the chipped stone collections came from SBa-1179, where the highest density of fire-altered rock of any of the sites investigated was also obtained. Both may be evidence of the utilization of plant parts such as cattail roots and shoots. The plant knives would have been used to obtain or prepare the plant parts, and the rocks would have been heated in order to roast them in covered pits.

However, fire-altered rocks, which occur at a number of the sites investigated, may actually be a reflection of stone-boiling, a procedure in which heated rocks are placed into a basket of gruel in order to cook it. If this was the use of the rocks, milled seeds or acorns would have been brought to the San Antonio Terrace sites, as mentioned above. At present, there is no definitive way of rejecting either of these two hypotheses regarding the use of heating stones, although the use in roasting seems to be more likely because of the abundance of marshland resources locally available.

<u>Plant Materials</u>

There is little evidence that different kinds of plant materials were collected for the manufacture of various kinds of facilities such as houses, traps and snares, or baskets. The most obvious evidence of the collection of plant materials is the presence of plant use-wear on chipped stone tool edges. Bamforth identified five such edges, three of which are from SBa-706. In addition, the plant knives mentioned above could have been the product of

processing either plant foods or plant materials, and no differentiation between these two uses is currently possible. A variety of woody plants are available on the San Antonio Terrace, the most popular of which may have been willow. Willow occurs in dense thickets in wetlands of the intermediate dunelands and along the San Antonio Creek. Softer plant parts such as those used in basketmaking are also widely available. Juncus grass (Juncus spp.) occurring in the intermediate dunes, and tules (or bullrush, Scirpus spp.) occurring in riparian wetlands are two plants known to have been collected by the Chumash for manufacturing baskets (Dawson and Deetz 1965).

Asphaltum

Small nodules of asphaltum occurred at four of the sites investigated, and it is likely that it is present at others, but was not encountered during excavations because of the very small size of the nodules and their relative scarcity. The Spanish expeditions passing through the San Antonio Terrace vicinity in the late eighteenth century noted that asphaltum-coated water baskets were used by the Chumash, and much of the asphaltum in the sites may have been derived from the loss of asphaltum from the sides of the baskets or the discard of unusable water baskets. However, deposits of asphaltum were also found clinging to the proximal ends of projectile points, indicating use as a fixative, so at least some of the asphaltum could have come from hafts or from the activity of rehafting. Surface features of asphaltum patty-like nodules were noted at SBa-706 and -998, implying that relatively large quantities of asphaltum were stored and perhaps used at these sites.

No tarring pebbles were encountered at any of the sites. These small tar-covered pebbles are frequent in certain other Vandenberg region sites (Glassow et al. 1981), and their presence would indicate the activity of coating water baskets. It appears, therefore, that while water baskets were used at project sites, the activity of coating them with asphaltum may have taken place elsewhere.

The precise source of the asphaltum has not been ascertained, but it is very likely that it was obtained from local beaches. Spanne (1974:7) notes that globules of asphaltum are available along the whole length of the Vandenberg coastline. He also indicates that natural seeps once existed in the Purisima Hills.

Heating Rocks

Fist-sized cobbles were brought to many of San Antonio Terrace sites for some sort of food preparation. Through use, they fragment into several irregular pieces and often become darkened in color. Mentioned above was the use of heated rocks for roasting and stone-boiling, and there does not seem to be any other plausible use of these rocks. The sources of the rocks could have been the cobble beaches occurring on the lee sides of Point Sal and Purisima Point or stream channels and coarse alluvial deposits in the

Casmalia and Purisima Hills. Igneous rocks were preferred, possibly for their relatively greater stability when heated in comparison to sandstone or quartzite.

Chert

Sources and use of chert were discussed in considerable detail in the analysis of the chipped stone collections presented in Chapter 9, and no further comments will be added here.

SETTLEMENT STRUCTURE

Introduction

A settlement structure is the manner in which a human population distributes itself over the landscape into settlements and the pattern of relationships which exist between spatially separated settlements and between each of these settlements and the natural environment. In the case of many hunter-gatherer populations, settlement structure is relatively fluid, changing over very short periods of time in response to a variety of social and environmental factors. Much of this variation is cyclical, in that the changes in settlement structure occurring through one year are repeated the next with only minor differences. These changes are usually in response to seasonal variations in those aspects of the environment to which a population is articulated (i.e., the resources on which the population depends). Other changes in settlement structure are in response to year-to-year fluctuations in the environment brought about by climatic variations. Again, settlement structural change is not permanent in that years with similar environmental conditions will be characterized by similar settlement structures. Still other changes in settlement structure are irreversible and have a directional quality over time. Such changes would be the expected result of gradual changes in average environmental conditions taking place over the course of many years.

The amount of human population that must be supported on the resources available in the environment also has an important effect on the nature of settlement structure. This is because of the balance which exists among and between population density, the combination of resources which a population exploits (including the amounts of each), and settlement structure. Under the well-known principal of least effort, populations will generally exploit resources that offer the highest return for the effort expended, and given that the economy of resource exploitation is dependent upon the intensity of exploitation, which in turn is dependent on population density, there will be adjustments to a population's resource repertoire as the relative economies of exploiting alternative resources change (Glassow 1978). Changes in a resource repertoire, whether in kind or intensity of exploitation, will normally require concomitant changes in settlement structure.

Bettinger and Baumhoff (1982) have recently couched these relationships between population density, resources exploited, and settlement structure in a theory of hunter-gatherer adaptive variability. They draw a contrast

between a "traveller" and a "processor" subsistence-settlement strategy in which the traveller type is characterized by relatively low population density, an emphasis on mobility, and reliance on relatively few low-cost/high return resources, and the processor type is characterized by relatively high population density, less mobility, and reliance on a broader spectrum of resources, many of which require a higher cost of procurement and processing for their return. While Bettinger and Baumhoff were interested in the evolutionary implications of this contrast, it also has relevance in comparisons between contemporaneous subsistence-settlement systems, or more specifically settlement structures.

Bettinger and Baumhoff (1982:488) point out the similarity between their traveller-processor contrast and Binford's (1980) forager-collector contrast, which was discussed in Chapters 2 and 9. Although Binford was not so concerned with the economics of subsistence strategies or the role of population density, he did give more attention to differences in settlement structure, which Bamforth discusses in Chapter 9. Because of this emphasis on settlement structure, greater attention will be given in the following analysis to Binford's forager-collector dichotomy. After evaluating the ethnohistorical data pertaining to settlement structure, attention will be given to defining the settlement types represented by the sites in the project area and the patterning in the geographic distribution of these types. This information will then be integrated with that from the San Antonio Terrace as a whole in an attempt to define aspects of subsistence and settlement of the regional system. Following this, evidence for variation through time will be evaluated, and brief comparisons with other regions will be made.

Ethnohistoric Evidence of Settlement Structure in the Vicinity of San Antonio Terrace

King identifies in Appendix I four and possibly five villages that were located within several kilometers of the San Antonio Terrace. The existence of named Chumash villages associated with specific locations, even though these locations are not yet documented through archaeological investigations, implies the existence of central bases and at least some degree of stability in residence location. At the same time, however, data cited by King also indicate the existence of a seasonal camp located on the southwestern edge of the San Antonio Terrace (this was discussed in Chapter 2). It is significant that this camp of 40 to 50 individuals contained no houses, as did the typical villages seen by the Spanish expeditions of the late eighteenth century, and that even the Spanish suspected it was a temporary village. It is also significant that the Spanish noted the occupation of this camp in late August 1769, but its abandonment in January, March, April, and May 1770. This implies that the site was not occupied during the winter and early spring, but was occupied during the late summer, if not also earlier.

The ethnohistorical data, then, document the existence of two kinds of settlements: a village base and a seasonal camp inhabited by a relatively large segment of a village population. The group occupying such a camp was made

up of both sexes, as indicated by the Spanish, and presumably whole families were present. In terms of Binford's classification of settlement types, the named villages would certainly have been residential bases because of their relative permanence, the existence of houses, and their use by a relatively large group. The camp seen by the Spanish on the southwestern edge of the San Antonio Terrace may also have been a residential base, even though houses were absent. This is suggested by the relatively large population segment camped at this spot, larger than some of the named villages in the vicinity, and the presence in the camp of people of both sexes and likely family units. The only other possibility is that this settlement was a field camp. Binford (1980:10) defines the field camp as a "temporary operational center for a task group," and his examples indicate that he has in mind settlements for the purpose of relatively specific exploitative activities carried out by relatively small population segments, such as males occupying a hunting camp. Although the available data regarding the nature of the camp seen by the Spanish are simply too scanty to resolve the question of what type of settlement it was, the classification as some sort of secondary residential base is the most plausible.

Regardless of the classification of this camp, the ethnohistoric data generally support the classification of the overall settlement structure as that characterizing Binford's collector strategy. If the settlement structure had been that characterizing foragers, the Spanish would probably have recorded much more mobility of the populations between different residential bases and would probably not so easily have identified a named village used by a population segment. Indeed, chances are the Spanish would have identified several, moreorless equally important camps used by a population segment. Assuming that the Chumash occupying the vicinity of the San Antonio Terrace at the time of Spanish contact were indeed collectors, the existence of three other settlement types are implied: "locations," where there is very short-term occupation (e.g., part of a day) for the purpose of extracting a particular resource, "stations," where information is collected on the behavior of a mobile resource such as game animals, and "caches," where resources are stored away from residential bases. Ethnohistoric evidence of these other settlement types has not come to light, but what is important here is that they would be expected on the basis of the ethnohistoric evidence indicating a collector subsistence strategy.

The distribution of the named Chumash villages as reconstructed by King appears to conform to a definite pattern. The villages of <u>Atajes</u>, <u>Lospe</u>, <u>Saxpil</u>, and <u>Estep</u>, as well as <u>Ajuaps</u> and <u>Naucu</u>, all are located next to or within the Casmalia Hills. Only <u>Nucsuni</u> is not located next to land of substantial relief, but King's placement of this village next to Purisima Point is very tentative; in fact, there is no site in the vicinity of Purisima Point which clearly could have been this village. (SBa-115, a large site at this point, does not have the density or diversity of midden debris found at certain sites on or near the flanks of the Casmalia Hills.) Furthermore, of those Purisimeño and southern Obispeño villages within 20 km of the coast,

those in or adjacent to the Casmalia Hills represent the greatest concentration, and the group includes the two largest villages. The population density represented by the seven villages mentioned above was between about 0.6 and 0.8 people per square kilometer, using King's village population estimates. The population density represented by the three Purisimeño villages immediately to the south of this group, Lompoc, Sipuc, and Nocto, is only about 0.5 to 0.6 people per square kilometer.

The concentration of population in the Casmalia Hills may be related to three factors: the protection from prevailing wind, the diversity of terrestrial habitat provided by the relief of the hills, and the existence of relatively long drainages with low gradients, which allows for the existence of marshlands as well as sources of fresh water. The protected slopes and canyons of the Casmalia Hills harbor live oaks, which provide acorns, a major Chumash food staple. The more exposed slopes are covered with plant communities containing various sages (Salvia spp.) and seed-bearing annuals. Marshland resources, including both plant and animal foods, would have been especially abundant along the bottomlands of the San Antonio Creek and along the northern edge of the Casmalia Hills adjacent to Orcutt Creek and other nearby tributaries to the Santa Maria River. To the south, the Santa Ynez River floodplain would also have offered extensive marshland resources, but the hills to the south do not appear to contain oak woodlands as extensive as those of the Casmalia Hills. This may be the reason villages were more dispersed in the southern part of the Vandenberg region. It should be emphasized, however, that these proposed relationships between environment and settlement are only suggestions which have to be evaluated in a rigorous study of the distributions and abundances of resources coupled with an attempt to pin down the actual locations of the historic Chumash villages of the Vandenberg region.

The Definition of Settlement Types in the Project Area

A settlement type may be defined as a group of sites at which a specific set of exploitative and maintenance activities took place (Struever 1971:11), and each activity of the set had a given importance in relation to the rest. Furthermore, all sites within a settlement type should have been articulated with a subsistence-settlement system in the same way; that is, their structural positions should have been identical. From an archaeological standpoint, sites within a settlement type contain different classes of archaeological remains in similar proportions to one another, although not necessarily in the same quantities or densities given that the frequency or extent of use might vary regardless of the structural position of the sites. The remains most important to the definition of a settlement type are those directly related to acquisition of food and other resources and the maintenance of tools and facilities.

Two outlines are presented below which summarize much of the preceeding discussion relevant to the definition of settlement types. The first outline, which presents the data classes and the activities each

represents, is meant to summarize the earlier discussion of resource procurement and use. It provides the basis for the second outline, which presents the kinds of data indicating three settlement types expected to occur on the San Antonio Terrace. This second outline will serve as a framework for evaluating the site data for the purpose of assigning sites to settlement types.

I. Activities Represented in Data Classes

A. Unmodified Flakes

1. Final stages of biface manufacture, perhaps at the time and place butchering takes place.
2. Indirectly, butchering of game animals.
3. Indirectly, hunting game animals, assuming completion of biface manufacture and butchering took place near where animals were hunted.

B. Preforms

1. Biface manufacture from intermediate stages on.
2. Indirectly, butchering of game animals, assuming preforms were knapped into finished bifaces at or near sites where animals were butchered.
3. Indirectly, hunting game animals, assuming preforms were knapped into bifaces near where butchering and hunting took place.

C. Projectile Points

1. Hunting game animals.
2. Butchering game animals, assuming that distal fragments and complete projectile points were discarded at the site where butchering took place.
3. Rehafting, assuming that proximal fragments of projectile points were discarded at the site where rehafting took place.

D. Chipped Stone Tools

1. Depending on edge wear characteristics, skinning and butchering animals, scraping hides, working wood, shell, bone, and dry hides, collecting or processing plant parts.
2. Indirectly, manufacture of tools and facilities, assuming that tools for working wood, shell, bone, and dry hides where used for such purposes.

E. Milling Implements

1. Processing hard seeds (principally manos and metates).
2. Processing acorns (primarily mortars and pestles).

F. Fire-Altered Rock
   1. Roasting pulpy plant parts.
   2. Alternatively, stone-boiling gruel in baskets.

G. Asphaltum
   1. In small pieces and sparing quantities, the use of asphaltum-coated water containers for water storage.
   2. In abundant quantities, especially as large pieces, the process of coating water containers or hafting projectile points and knives.

H. Bone (culturally deposited)
   1. Consumption of the particular species represented by the bone, especially if the bone is burnt.
   2. Primary or secondary butchering, especially if butcher marks are present (Note: The presence of bone in the small pieces and quantities in the collections does not allow primary and secondary butchering to be differentiated.)

I. Shellfish Remains
   1. Consumption of particular species of shellfish remains.

II. Indicators of Settlement Types

A. Day-Use Locations (Binford's locations and stations)
   1. Presence of tools devoted to procurement and initial processing of resources: projectile points, bifaces, skinning and butchering tools, plant knives, possibly hide scrapers, possibly preforms, possibly waste flakes representing the last stages of biface manufacture.
   2. Lack or minimal abundance of tools devoted to maintenance, that is, to manufacture of tools and facilities: tools for working shell, bone, and dry hides.
   3. Lack or minimal evidence of water storage: small pieces of asphaltum.
   4. Lack or minimal abundance of items relating secondary food processing: fire-altered rock, milling equipment, charcoal and ash.
   5. Lack or minimal abundance of portable food remains, especially foods that are preserved or will stay fresh for a day or two: fish remains, shellfish remains.

B. Overnight or Short-Term Occupation Camps (Binford's field camps)
   1. Moderate to high abundance of tools devoted to acquisition and initial processing of resources: as above.

2. Minimal abundance of tools devoted to maintenance activities: as above.
3. Evidence of water storage: asphaltum in small pieces.
4. Minimal to moderate abundance of portable food remains: fish bone and shellfish remains.
5. Minimal to moderate abundance of items related to secondary food processing: as above.

C. <u>Seasonal Residential Bases</u> (especially those occupied during summer-fall)

1. Moderate to high abundance of tools devoted to procurement and initial processing of resources: as above.
2. Moderate to high abundance of tools devoted to maintenance activities, including coating basketry water containers or hafting with asphaltum: as above, including potentially asphaltum, some of which is in large pieces.
3. Evidence of water storage: as above.
4. Moderate to high abundance of items related to secondary food processing: as above.
5. Moderate to high abundance of food remains representing all major food resources available in the site catchment during seasons of occupation.

The definition of the three settlement types in terms of archaeological indicators implies that there is a continuum between sites that were frequently used residential bases and sites that may have seen one day's use. To a degree, this is true. It may be difficult, for instance, to differentiate between sites used once as field camps for only a few days and sites which were day-use locations used repeatedly, but never overnight. Nonetheless, there should be a relatively strong dichotomy between sites of these two types and sites which served as residential bases. The latter stand a much higher chance of having been regularly used, if only seasonally, for many years, and the duration of occupation during a given year should be significantly greater than that of field camps, which would otherwise share many of the characteristics of residential bases. The differentiation between residential bases on the one hand and overnight camps and day-use locations on the other therefore depends on relatively sharp contrasts in the densities of different classes of occupational debris. Beyond this, residential bases should contain significantly higher proportions of items relating to maintenance activities, as pointed out by Bamforth in Chapter 9.

As an aid to classifying the sites investigated in the project area into settlement types, Table 10-1 was prepared. This table abstracts data presented in Chapter 9 for those sites included in one or more of the different collections analyses and at which excavation of some sort took place (excluding nonaboriginal sites). There are too many vagaries in the data

Table 10-1. Summary of Data Pertaining to Sites Investigated.

SBa-Site Number	Geographic Zone	Age and Number of Project Points	Number Processing Tool Edges	Number of Maintenance Tool Edges	Flake Number Per Meter³	Bone Number Per Meter³	Shell Number Pet Meter³	Number of Preforms	Number of Large Bifaces	Fire-Alterned Rocks Per Meter³	Asphaltum Presence	Number of STPs	Volume in Meter³ in Unit	Settlement Type 6
581	No	R-1	1	1	2.2							13		
704	B		1	0				1				5		
706	S	R-2	12	7	50.6	133 NA	1.82	4	3	2.5	P	132	11.6	SRB
980	S	R-1	5	2	201.0	20 NA	0.48	2		2.5	P	2	2.0	SRB
998	S	E-1	2	0	2.9		T		1	1.4		163	1.4	OHC-E
1036	S		4	0	7.9		T	0	0	0.1		36	19.7	OHC-L
1037	S				200.0	P NA						4		DHL-M
1038	S	R-1	5	1	34.8		T	2				35	2.8	DHL-M
1052	H				2.6								1.0	DHL-L
1070	S	R-2	4	0	165.4	13 A	0.65		2	1.2	P	26	1.2	SRB
1070E	S	R-1	2	0	1.0		T		1			1	3.9	DHL-L
1153	No						T					22		
1154	No						T					18		
1155	I		0		0	1.4	7 NA		1			111	2.0	DHL-L
1170	I	E-I	2	0	73.7				1	0.3		10	4.0	DHL-L
1173	I	E-I	1	0			T	0	0			67	6.7	DHL-L
1174	H	E-2	5	6	15.2	126 A	T			3	P		2.86	?
1176	I		0	0				1				19	15.4	DHL-L
1177	I	R-4	5	0			T			1		27	14.2	DHL-L
1179	No	R-1	9	1	0.9	27 A	29.4	3		3.1	P	48	16.0	OC-P
1180S	No	E-1	1	0	9.8	0				1	P		2.4	OHC-L
1181	I	R-1	4	0	16.7		T		1			8		DHL-M
1193	S						T			P		373	75.1	DHL-L
1682	I									P		83		
1683	I						T					49		
1718	No	E-1	1	0	13.5	17 A	0.32	0	0	P		55	3.1	OHC-M

[a] Densities of shellfish remains were provided by J. Serna and do not appear in Chapter 8.
[b] Codes are first letters of type names presented in text.

Codes: C=central portion of dunes, B=northern edge of Burton Mesa, S=southern edge of San Antonio Terrace, H=Flanks of Casmalia Hills, I=intermediate area between terrace edge and northern portion of dunes, No=northern portion of dunes, R=recent, E=natural deposition, A=cultural deposition; T=trace quantities; P=present

presented in this table to justify an elaborate statistical analysis to discover patterns of association between site characteristics. Instead, the following classification is based on visual inspection of the data. Of all the site characteristics included in the table, the densities of flakes, bone, and shell are probably the most reliable, especially for sites at which unit excavation was undertaken. The density of fire-altered rock and the presence of asphaltum are also fairly reliable data, but only for sites with unit excavation. The frequencies of projectile points (many from site surfaces), chipped stone tools, and preforms have not been converted into densities since their low numbers per site would make this relatively meaningless. Indeed, their absence at many of the sites may reflect the lack of very extensive excavation. Because of the greater reliability of the flake, bone, and shell densities, relatively more dependence is placed on these data in developing the classification. The density of fire-altered rock and the presence of asphaltum are given some importance as well.

Seasonal Residential Bases: SBa-706, -980, and -1070 form the most distinctive group in comparison to nearly all the other sites. All three are of relatively large size. In fact, they are contiguous and are connected with each other by low-density scatters of flakes, occasional shellfish remains, and sporadic fire-altered rocks. All three also have relatively obvious midden deposits associated with soil discoloration. The data in Table 10-1 indicate that chipped stone tools are relatively frequent, and flakes are in high densities. Shell and bone are in moderate to high densities, as is fire-altered rock. All three sites contain asphaltum, and SBa-706 is known to have a surface feature containing large patty-like lumps of relatively pure asphaltum. These three sites are the best candidates for seasonal residential bases. This interpretation is based not only on the degree of midden development and the relatively high densities of artifacts and other residues, but also on particular characteristics of the collections most distinctive of residential activities, in particular, the considerable diversity of species represented in the faunal remains, the wide variety of chipped stone tool types, and the relatively large size of some of the chunks of asphaltum. Significantly, ground stone artifacts are absent. This implies that seeds or acorns were not collected or processed while people resided at these sites. Perhaps these sites were occupied during seasons when seed and acorn resources were not important components of the diet--most likely in late summer and early fall. In this regard, it is noteworthy that the seasonal site encountered by the Spanish expeditions in August, 1769, could not have been more than a kilometer or two from these sites. Although that particular site has not been identified, it would expectably resemble the sites in this group.

SBa-998 should probably also be placed in this group, even though the collections from this site do not indicate this. Since the collections appear to have come from marginal or disturbed deposits, they do not represent the site as a whole. Other areas of the site have relatively high surface densities of a considerable variety of cultural remains, similar to what is found on the surfaces of the sites certainly included in this type.

Overnight Camp (perhaps with emphasis on plant food processing): SBa-1179 is clearly in a class by itself, at least insofar as the representativeness of the project area data can be trusted. This rather small site with relatively distinct zones of soil discoloration contains densities of bone, shellfish remains, and chipped stone tools resembling those at the sites identified above as residential bases, but it contains a rather low density of flakes. The density of fire-altered rock is the highest of those sites investigated, and asphaltum occurring in small pieces is widely scattered through the site. Its small size, lack of true midden development, and relatively even distribution of small chunks of asphaltum suggest that this site is not a residential base, but instead a short-term occupation site used perhaps only several times.

The unusually high density of fire-altered rock in association with patches of darkened soil containing flecks of charcoal (Features 1 and 3) imply that some sort of roasting occurred at this site, perhaps of pulpy plant parts (e.g., roots and lower stems of Typha). This inference is supported by the presence of tools identified as plant knives, the only such tools identified in the project area collections.

Overnight Hunting Camps, Less Frequent Use: SBa-998, -1036, and -1180S comprise a loose grouping characterized by moderate densities of flakes, a few game processing tools, and a trace or lack of bone and shell. The occurrence of fire-altered rock at these sites suggests that overnight activity took place. Although no asphaltum occurs in the collections from these three sites, SBa-998 is known to contain a surface feature containing a fragmented patty-like lump of asphaltum like the ones noted at SBa-706 nearby. As mentioned above, debris on portions of the surface of SBa-998 resemble more the collections from the seasonal residential base sites, and this site is therefore possibly spuriously classified with SBa-1036 and -1180S.

Overnight Hunting Camp, More Frequent Use: SBa-1718 is another site seeming unique unto itself. It contains moderate densities of flakes and bone, and fire-altered rock is present. Chipped stone tools are rare at the site, and shell is in rather low densities. It has some similarities to the last group discussed, but bone and shell are more abundant at SBa-1718. This may mean that this site was a more frequently used overnight hunting camp.

Day-Use Hunting Locations, More Frequent Use: SBa-1037, -1038, -1170, and -1181 may be sites which witnessed no overnight stays, but were spots where game animals were butchered before transport to overnight camps or residential bases. Flakes are in moderate to high densities, a few meat processing tools are present, and bone, shell, and fire-altered rock are either absent or in very low quantities. No asphaltum was encountered at these sites. The minimal amounts of food remains and high densities of flakes along with a few meat processing tools imply that the focus of activity was on processing game animals rather than preparing food. Classification as day-use sites therefore seems most appropriate.

Day-Use Hunting Locations, Less Frequent Use: The remaining sites listed on Table 10-1 yielded comparatively few of any class of remains, flakes being the most frequent item occurring. At a number of sites, however, the amount of excavation is not sufficient to be confident of what the site contains. More confidence exists for sites at which there was unit excavations, including SBa-1052, -1070E, -1155, -1173, -1176, -1177, and possibly a small portion of SBa-1193 apparently representing an intact deposit. The remaining sites, at which only STPs were excavated, cannot be confidently placed in any group, although the available data hint that they may be classed with the above.

The paucity of cultural remains at these sites and the presence of occasional chipped stone tools suggests that these sites were used very few times as locations for processing game animals.

Comments on the Settlement Typology: This classification of the sites just presented should be viewed as very tentative in light of the considerable variability between sites in the nature of the samples of archaeological materials. The greatest distinctions within the classification are between the Seasonal Residential Bases on the one hand and virtually all the other sites on the other. Only SBa-1179 does not clearly fit into one of these two major divisions, although it is fairly certainly not a residential base. This distinction between sites presumed to be residential bases and sites of the other settlement types would be expected, as previously discussed.

If the distinction between Overnight Hunting Camps and Day-Use Camps is to hold up when better samples of data become available from the study area, there should be consistent differences in the proportions of different classes of artifacts and other cultural debris. Specifically, debris that are associated with culinary activity and perhaps also temporary shelter construction should be significantly higher in proportion at Overnight Hunting Camps. Classes of items would include fire-altered rock and woodworking tools. Hearth remains (such as darkened patches containing charcoal) might also be present where deposits have not been significantly disturbed by wind erosion. Conversely, Day-Use Camps should contain significantly higher proportions of tools related to resource procurement and initial processing, especially chipped stone tools. As it stands now, there is some difficulty in differentiating between Overnight Hunting camps used only a few times and Day-Use Camps used many times.

All of the sites, even the residential bases, appear to be devoted to activities related to hunting; only SBa-1179 appears to depart somewhat from this generalization. The emphasis on hunting is expectable since the environment surrounding the site does not offer much beyond animal food resources. Nonetheless, for reasons discussed in the previous section on resource procurement and use, the wetlands may have provided more plant food resources to the inhabitants of the San Antonio Terrace than is apparent in the archaeological record.

Although the remains of marine foods--fish and shellfish--occur in the sites and tend to be more abundant in the residential bases, these resources appear not to have been very important. Sites located directly on the coast, especially near Purisima Point and Point Sal, contain much higher densities of marine food remains, and it therefore appears that most of the consumption of these resources took place at coastal sites. The relationship between the residential bases in the project area and coastal sites in the wider study area will be discussed below.

Geographic Distribution of the Settlement Types

For the purpose of investigating the geographic distribution of the sites within each settlement type and comparing these distributions between types, five geographic zones have been defined. The definition of these zones is dependent in large part upon the locations of sites investigated. That is, the zones partition the project area (as opposed to the study area) into a series of units for purposes of studying geographic variations. For those sites within or immediately adjacent to the intermediate dunes, distance from the San Antonio Creek bottomlands is considered to be an important variable because the higher resource potential of these bottomlands likely exerted a strong pull on settlement. The remaining sites in the project area fall into two discrete clusters relatively isolated from those sites associated with the intermediate dunes, and each cluster is therefore treated as a distinct geographic zone. It should be noted that if sufficient information were available from all the sites of the study area, a more complex and sophisticated approach to studying geographic variations between sites would be possible, perhaps one which involved different kinds of geographic divisions than are used here.

Three geographic zones are defined for those sites within or immediately adjacent to the intermediate dunes. Although the boundaries between the zones are based on apparent variations in the density of sites, the defining variable, as just mentioned, is distance north of the San Antonio Creek bottomlands.

The southernmost of this set of three is defined as the southern edge of the San Antonio Terrace and is meant to include those sites that are near the San Antonio Creek and are frequently connected to neighboring sites by low-density scatters of cultural remains (SBa-706, -980, -981, -998, -1070, -1036, -1037, -1038, among others). Immediately north of this zone, well within the intermediate dunes, is the intermediate zone, which appears to contain a lower density of sites than in the zones to the north or south. However, this may be a product of less extensive survey in this zone, which was generally confined to corridors along roads (see Figure 1-2), but the impression is that this is not the case. This group of sites includes SBa-535, -1155, -1170, -1173, -1177, -1178, -1181, and -1687. These sites tend to be relatively small and discrete in comparison to those in the southern terrace edge group. The northernmost group, in the northern zone, consists of what appears to be a relatively high concentration of sites, most of which are small

but a few of which are relatively extensive. All of these sites are immediately north of a major wetland complex in which standing water has existed through the course of the project. Included in this zone are SBa-540, -557, -581, -1153, -1154, -1179, -1180, -1180S, -1682, -1683, and -1718, among others.

A fourth group of sites includes those in the northeastern corner of the San Antonio Terrace, actually slightly beyond the terrace proper into the lower flanks of the Casmalia Hills. SBa-1052 and -1174-1175, are the only sites investigated of this group, which could be construed to include a considerable concentration of sites just beyond the study area within the Casmalia Hills. Reliable data on prehistoric use come only from SBa-1052, so this zone cannot effectively be considered in the analysis.

The fifth group consists of a few sites on the southern edge of the San Antonio Terrace where the project area extended southward. SBa-592, -704, and -1172 comprise this group, and since so little data came from these sites, this group will also not be included in the analysis.

Turning now to the manner in which the sites of each settlement type are distributed through these zones, the data are summarized in Table 10-2. The sites classified as seasonal residential bases occur only in the zone comprising the southern edge of the San Antonio Terrace. All of the other settlement types for which there is more than one site are distributed in two or three zones. Interestingly, however, the day-use hunting locations tend to be located in the San Antonio Terrace edge and the intermediate zones, whereas the over-night camps for hunting or plant food processing show some tendency for being located in the northern zone. Although the frequencies of sites are too low for much confidence in this distinction, there is an apparent reason for this pattern. The San Antonio Terrace edge and the intermediate zone just north of it tend to contain sites on two extremes of the spectrum: either sites with considerable evidence of occupation and use or sites with comparatively little evidence of occupation or use. Even the two sites classified as over-night hunting camps are among those with lesser densities of cultural materials. This kind of pattern would be expected if the distances between where food was obtained and residential bases is comparatively short, allowing for food resources to be transported to the residential base during the day the food was procured. The northern zone, however, is about 2 km from the residential bases over difficult-to-traverse terrain, thus favoring the establishment of overnight camps that would tend to be used time and again. The northern zone is also comparable distances from sites to the north and east which might have served as residential bases.

Subsistence-Settlement Systems of the San Antonio Terrace

The sites investigated in the project area clearly are part of a larger regional settlement system, and to gain an understanding of the regional settlement system, attention must be given to the full range of site types, and knowledge must exist of their distributions within the region. While comparatively little information exists for sites outside the project area, data

Table 10-2. Distribution of Sites By Settlement Type, Geographic Zone, and Time Period.

Settlement Types	San Antonio Terrace Edge	Intermediate Zone	Northern Zone	Flanks of Casmalia Hills	
Seasonal Residential Base	3 (R,R,R)*				3
Overnight Camp, Emphasis on Plant Food Processing			(R)		1
Overnight Hunting Camp, Less Frequent Use	2 (E)		1 (E)		3
Overnight Hunting Camp, More Frequent Use			1 (E)		1
Day-Use Hunting Location, More Frequent Use	2 (R)	2 (E,R)			4
Day-Use Hunting Location, Less Frequent Use	3 (R)	4 (E,R)		1	8
Total	10	6	3	1	20

*R=Recent, E=Early; each R and E represents one of the sites included in the cell frequency given immediately above.

from surveys undertaken since 1969 provide some data relevant to recognized aspects of settlement structure and the subsistence-settlement systems which created this structure.

While the San Antonio Terrace as a whole appears to contain a diversity of site types greater than that represented in the project area, it also is probably too small to contain the full diversity that was produced by the prehistoric inhabitants who used the terrace. This inference is based on the fact that the historically recorded aboriginal Chumash villages are located on the very edge of or beyond the San Antonio Terrace boundaries. Mentioned in an earlier section was the apparent association between Chumash village locations and hilly lands, implying that the resources of higher-relief lands beyond the San Antonio Terrace were probably quite important aboriginally. Sites within these zones expectably would yield more evidence of the collection and utilization of plant foods, especially acorns, and the historically recorded Chumash villages undoubtedly reflect the importance of these resources. Support for a greater emphasis on collection and processing of seeds and acorns comes from survey data obtained by Spanne (1974:20-22) between 1969 and 1973. Sites on the northern edge of the terrace (beyond the limits of the intermediate dunes) and into the Casmalia and Purisima Hills contained ground stone artifacts. Only one site outside lands of greater relief (SBa-982) contained a ground stone artifact.

With regard to the existence of settlement types in addition to those already defined, one obvious type that must exist consists of the named Chumash villages and other comparable sites that may have been used in a similar way earlier than the protohistoric period. In his preliminary analysis of the 1969 to 1973 survey data, Spanne (1974:9) defined a category he referred to as "sedentary or semi-sedentary villages," which may include one or more of the named Chumash villages. In the vicinity of the San Antonio Terrace, Spanne identified two clusters of sites falling into this category, one consisting of four sites near the mouth of Shuman Canyon (SBa-512, -513 -941, -734, and -940), and the other consisting of two sites in the Casmalia Hills just northeast of the San Antonio Terrace (SBa-782 and -783). These sites tend to be relatively large in area, they have well developed middens of relatively great depth, they contain cemetery areas, and they are located near fresh water and a variety of resource areas. If the ethnohistorical data are indicative, these sites were probably occupied during the greater part of the year, specifically during the fall, winter, and early spring. Expectably, they would be residential bases with evidence of more permanent habitation (i.e., house floors) and a greater variety of maintenance activities in comparison to the seasonal residential bases in the project area.

Other types of residential bases may also exist, but these appear to be much less intensively used as such compared to those just described. Spanne (1974:9-10) defines a site type he calls "seasonal villages or intermittently occupied habitation sites," which includes a number of sites scattered around the periphery of the San Antonio Terrace and includes all the seasonal residential bases defined for the project area (although his type also includes

sites representing other settlement types defined above). Spanne notes that sites in this type are also relatively large in area and have relatively well developed midden deposits, but they are shallower sites, with less evidence of associated cemeteries. Location adjacent to a permanent fresh water source is less consistent, and they seem to be placed so as to exploit efficiently only one or very few classes of resources. Two variants appear to exist: those adjacent to or very near the coast, containing relatively more evidence of the exploitation of marine resources, and those located inland for the exploitation of terrestrial resources. Some of the latter may be more oriented toward collection of plant foods while others may be more oriented toward hunting.

Two final types which cannot be differentiated on the basis of available data, but can be inferred on the basis of what is known of Chumash subsistence, are overnight camps devoted to collection of acorns and other types of plant foods and day-use locations for essentially the same purpose. Landberg (1965:102-103) also hypothesizes the existence of such settlement types in his model of the Santa Barbara Channel Chumash subsistence-settlement system.

In the end, only a hazy picture emerges of subsistence-settlement systems that involved the San Antonio Terrace. The available data from the study area and the surrounding area give the impression of intersite mobility organized around the use of residential bases. From these residential bases, people ranged out to use at least two other major classes of settlements: one for overnight stays and another for day-use. This logistically organized settlement system was superimposed over three major resource zones: the coast, the San Antonio Terrace, and the hilly lands to the north and east. It is likely that residential bases were located in each of these major resource zones and that subsistence-related activities at each type of residential base reflect the kinds of resources exploited within the surrounding zone. As the analysis of data from the project area reveals, residential bases located on the edge of the San Antonio Terrace appear to have been oriented toward hunting terrestrial game. Those on the coast would expectably be oriented toward shellfish collection and fishing, which would account for the considerable densities of these food remains in many of the coastal sites. Those immediately adjacent to or in the Casmalia and Purisima Hills, which apparently include the historic Chumash villages, appear to reflect a relatively greater emphasis on plant food resources, although these sites are positioned so that resources from both the San Antonio Terrace and the hilly lands could be exploited. As Spanne (1974:9) recognized, these sites are the most strategically located to exploit a wide variety of resources.

Ideas on the nature of subsistence-settlement systems in the vicinity of the San Antonio Terrace proposed recently by Neff (1982:80) may also be fit into this model. He noted that sites near the mouth of Shuman Canyon, including those identified by Spanne as "sedentary or semi-sedentary villages" and "seasonal villages," contain chipped stone waste representing all stages of manufacture, whereas a cluster of sites on the southeastern edge of the San Antonio Terrace contain flakes representing only the final stages of

manufacture, similar to virtually all the sites in the project area. On the basis of data from these two site clusters, as well as data from sites on other parts of Vandenberg, Neff argued that two types of stone tool production occurred, one in which all stages of stone tool production are done at one site and another in which the initial stages are accomplished at sites different from those where the final stages take place. Actually, these two strategies could be practiced simultaneously by one group of people. At residential bases near sources of chert, such as those found near the mouth of Shuman Canyon north to Point Sal, some types of tools could have been made from beginning to end of the manufacturing process, whereas only the initial and intermediate stages of the manufacture of other tool types were completed. Bifaces, for instance, that were used for hunting at residential bases and satellite overnight and day-use sites away from the chert sources may have been manufactured only to the preform stage at sites near the mouth of Shuman Canyon.

Temporal Variations

As already discussed in Chapter 7, all the sites in the project area are thought to have been occupied relatively late in prehistory, most likely within the last 2,000 years. However, very few sites could be firmly dated, and recourse was made to projectile point types in an attempt to categorize the sites into different time periods. Two time periods were recognized: early and recent, but due to poor temporal sensitivity of certain of the projectile point types, these two periods cannot be firmly related to existing regional chronologies, nor can there be high confidence that the time periods are completely distinct.

In his analysis of the chipped stone collections presented in Chapter 9, Bamforth endeavored to use the two-part chronology to investigate the possibility that some of the variability in the site collections was the result of change through time, and he was able to discern patterning in the data that appeared to be consistent with the dating of the sites on the basis of projectile point types. To summarize his conclusions, he found that sites classified as early tended not to be as clearly differentiated into settlement variants as those classified as late. Specifically, there appears to be considerably less emphasis on activities related to maintenance and repair of tools at early sites of the project area than at recent sites, implying that these activities took place at sites beyond the project area during the early period and that early period populations were apparently somewhat more mobile than those of the late period. This inference was supported by the absence of preforms and the presence of flakes representing only the very last stages of biface manufacture in early sites, whereas performs and flakes representing a greater number of the final stages of biface manufacture were found at late sites. He also found that early period populations apparently placed more emphasis on "curating" chipped stone tools than was the case during the recent period, as reflected in the lower rates of discard of usable tools in early sites in comparison to recent sites.

Up to this point in the analysis of subsistence-settlement systems that included the San Antonio Terrace, the possibility of temporal variation has not been considered. There were two reasons for this. First, the sites included in the subsistence-settlement systems analysis are somewhat different from those used by Bamforth in his analysis, and of the 20 sites included in this analysis, only 13 could be assigned to one of the two time periods on the basis of points present. Second, it makes sense to focus initially on the functional differences between the sites and then to consider whether some of the functional differences can be seen to vary through time as well as space.

In an effort to determine the extent to which time might be represented in the settlement type classification and the spatial distributions of each settlement type, Bamforth's temporal assignments were included in Table 10-1 and are also reproduced on Table 10-2. The data in the latter table are most pertinent to present analysis. Most readily observable in this table is the fact that all three of the sites classified as seasonal residential bases fall within the recent period. Other patterning is less apparent, or at least more difficult to demonstrate. There is some possibility that a different sort of functional variation exists among the late sites in comparison to the early sites, even if the seasonal residential bases are excluded from consideration. The one recent overnight camp with an apparent emphasis on plant food processing is of course obvious, but there is only one site in this category in any regard. Beyond this, however, all recent sites are classified as day-use hunting locations, whereas early sites are classified as both overnight camps and day-use hunting locations. There is perhaps also a greater tendency for early sites to be located farther from the San Antonio Terrace edge than recent sites, but this pattern is far less apparent.

What these patterns might indicate is that the existence of seasonal residential bases during the late period tended to act as a "pull" on subsistence activities. In other words, the existence of bases tended to reduce the incentive to establish overnight camps on the San Antonio Terrace and enhance the use of day-use locations. During the early period, when residential bases were apparently fewer and farther between, there would have been more incentive to establish overnight camps. The pull of the recent period residential bases may also have reduced forays into the northern zone, farthest away from the southern terrace edge, except for more specialized activities such as collection of plant resources.

If these interpretations are correct, the conclusions regarding the nature of subsistence-settlement systems presented in the previous section would have to be modified somewhat. Instead of perceiving essentially one subsistence-settlement system in which hunting near residential bases made use of nearby day-use locations and overnight camps at some distance from the bases, two different subsistence-settlement systems are perceived. The earlier involved no residential bases in the project area and instead emphasized relatively more the use of overnight camps, while the later did involve residential bases but relatively less use of overnight camps. These two interpretations may be perceived as alternative hypotheses that should be tested against more and higher quality data before one could be favored over the other.

There is one other dimension to the consideration of temporal change, this being the apparent lateness of all occupation in the project area regardless of whether this occupation can be divided into two periods. In Chapter 7 it was pointed out that the duration of occupation in the project area may correlate with the time during which the intermediate dunes have been in place approximating their current form, and in Chapters 4 and 5 it was argued that the intermediate dunes are not older than 2,000 years. The fact that the intermediate dunes comprise such a distinct aeolian unit compared to the old dunes underlying and beyond them implies that there is some separation in time between the formation of the old and intermediate dunes, which is consistent with a variety of other data presented by Johnson in Chapter 4. Interestingly, the formation of the intermediate dunes appears to correlate with a period of warm sea water temperatures documented by Pisias (1978) on the basis of an analysis of fossil radiolaria from sediment cores taken from the bottom of the Santa Barbara Channel. His reconstructed paleotemperature curve (Pisias 1978:380) indicates that beginning around 2,000 years ago sea temperatures became significantly warmer than before, reaching maximum temperatures approximately 5°C warmer than present between about 1,500 and 800 years ago. Pisias (1979:384-385) argued that warm sea temperatures would be correlated with warm air temperatures and higher annual precipitation, but others have argued that Holocene climatic warming trends are associated with less precipitation, not more (Heusser 1978:676; Axelrod 1981:851). Indeed, it would make more sense that conditions were drier than present between 1,500 and 800 years ago if this was the period when the intermediate dunes were active, and interpretation that better fits Heusser's (1978) fossil pollen data coming from the same sediment core from which Pisias extracted the radiolaria for his study. Huesser (1978:676) notes that chaparral communities do not become prevalent until after ca. 2,200 years ago, and she proposes that these communities would expectably have expanded during relatively dry climatic conditions.

If the intermediate dunes were more active between ca. 1,500 and 800 years ago, human populations living in and around the San Antonio Terrace at that time must surely have been affected. Specifically, because of lowered productivity of forage plants, the zone of the intermediate dunes would not have provided as many game animals during this period, and utilization of the terrace would therefore have been lowered. The greater mobility which Bamforth argued characterized the early period, which would have correlated with this period of increased aridity, may have been at least in part a product of lower terrestrial productivity, which in turn may have lowered human population density. When conditions became more hospitable after about 800 years ago, it may have made more sense to establish residential bases on the southern edge of the San Antonio Terrace.

If the paleoenvironmental changes just outlined occurred, it must be argued that sand supply on the beaches would be sufficient during periods of aridity to allow the intermediate dunes to be produced and periods of increased precipitation would not necessarily be associated with increased

sand supply or, regardless of sand supply, with dune activity. There is the possibility, however, that greater precipitation increases the supply of sediments in the rivers and streams, which in turn increases the supply of sand on local beaches and therefore the rate of movement of dunes. If these relationships are correct, the model of cultural responses to environmental change just outlined would not hold. It is noteworthy, however, that the postulation of greater dune activity during periods of greater precipitation does not appear to fit well with the available paleoenvironmental information. Furthermore, it should be pointed out that increased regional precipitation improves the quality of watersheds and may therefore not necessarily cause an increase in sediments entering rivers and streams and eventually ending up on beaches. The inceased sedimentation which has occurred historically may ultimately be the result of widespread agriculture and stock grazing. Clearly, more archaeological and paleoenvironmental data must be obtained if the ideas presented here are to be properly evaluated.

Comparisons with Other Portions of the Vandenberg Region and Beyond

Unfortunately, few large areas of the Vandenberg region have been subjected to intensive survey, and much of the excavation data which exists has not yet been completely analyzed. Comparisons with other portions of the Vandenberg region must therefore remain relatively general and tentative. Immediately to the south of the San Antonio Terrace, on Burton Mesa, a few intensive surveys of isolated blocks of land (Glassow et al. 1976; Glassow 1977) and Spanne's more extensive (than intensive) survey (Spanne 1974) have revealed that site densities appear to be much lower except along the peripheries of the mesa overlooking the San Antonio Valley, the Santa Ynez Valley, and the coast, where densities are perhaps as high as on the San Antonio Terrace. There is not the hummocky intermediate dune topography with associated wetlands on Burton Mesa, and game animals may therefore be in lesser densities and not so "patchy" in their distribution. Utilization of Burton Mesa by aboriginal hunters may therefore have been less than on the San Antonio Terrace.

Surrounding the other sides of the San Antonio Terrace to the north and east are the Casmalia and Purisima Hills and, as already mentioned, these lands appear to contain a number of substantial sites easily meeting the definition of the residential base. However, intensive surveys sufficient in size for inferring the overall site variation and distribution have yet to cover areas in these hills, but indications are that many sites are significantly more complex than those of the San Antonio Terrace in that they contain greater densities and varieties of cultural remains.

On south Vandenberg intensive survey is largely restricted to a 900 m strip running along the coastline from the Santa Ynez River to Sudden Ranch. From Santa Ynez River south to Honda Canyon, coastal dunes that are probably coeval with the intermediate dunes of the San Antonio Terrace cover this strip, and are largely restricted to it. The nature and distribution of sites within these dunes strongly resembles that of the San Antonio Terrace in that

the predominant constituent in the site deposits is chipped stone, and an emphasis on hunting and processing game animals appears to have been the dominant activity. From Honda Canyon southward, however, the intermediate-type dunes are largely absent, and the coastline is dominated by rocky intertidal zones in comparison to the straight, sandy beaches immediately to the north. From these rocky intertidal zones shellfish were obtained, and many of the sites therefore have well-developed middens and have been demonstrated through testing to have substantial areas and depths (Glassow et al. 1976). Comparatively little is known of the nature and distribution of sites inland from the coastal strip on south Vandenberg because not even Spanne's 1969 to 1973 survey covered much of this area. The impression is that sites are in relatively low densities, especially when compared to sites in the Casmalia and Purisima Hills, although some large sites with dense deposits are known to exist in the major drainages.

In comparison to other areas on the base, the San Antonio Terrace appears to have been a zone ideal for hunting game animals such as deer and rabbit. Indeed, there may not have been another tract of land as large anywhere else in the Vandenberg region where hunting, especially of deer, could be as effectively carried out. While other areas of Vandenberg may have had comparable densities of deer and other game, the extensive intermediate dunes of the San Antonio Terrace produce the relatively unique situation of frequent patches of vegetation where game congregates, which would potentially increase the efficiency of hunting. At this point in the development of knowledge, however, this argument must still be carefully evaluated against more detailed environmental and archaeological data before it can be accepted as a plausible explanation of the differences in the nature and distribution of sites between the San Antonio Terrace and other areas in the region.

Looking farther afield, a few comments may be added regarding the differences between the Vandenberg region and the coastal mainland zone of the Santa Barbara Channel. In the first place, there are no lands along the Santa Barbara Channel mainland which resemble the San Antonio Terrace. There are very few and small patches of dunes, and the Santa Ynez Mountains rise within a few kilometers of the coast, thus eliminating the potential for extensive marine terraces such as the San Antonio Terrace and Burton Mesa on Vandenberg. Furthermore, deer and other important game animals are in lower densities, but aboriginal human populations were in higher densities along the Santa Barbara Channel. As a result of these factors, terrestrial hunting does not appear to have been as important during the latter part of prehistory as in the Vandenberg region, and few sites can be identified as largely devoted to hunting. In fact, Santa Barbara Channel sites inland from the large coastal villages appear to have been devoted more to collection of plant food resources. Overall, the density of small sites probably serving as field camps and locations appears to be significantly lower along the Santa Barbara Channel, although intensive survey has not covered sufficiently large areas along the Santa Barbara Channel for this comparison to be certain. Nonetheless, during the last 2,000 years there appears to have been a

greater degree of sedentism and a lower degree of intersite mobility among the occupants of the Santa Barbara Channel than was the case in the Vandenberg region, a situation expectable in light of the greater emphasis on marine fishing and probably also sea mammal hunting along the channel.

Chapter 11

FUTURE RESEARCH DIRECTIONS AND MANAGEMENT CONSIDERATIONS

INTRODUCTION

As a conclusion to this study, two closely related topics are discussed. The first, future research directions, considers how any research undertaken on the San Antonio Terrace at some time in the future might build upon the accomplishments of the Vandenberg MX Archaeological Project. The second topic, management considerations, is concerned with the development of strategies and procedures for conserving archaeological resources and maximizing the amount of useful information that can be generated from them when they are impacted by land development. These two topics should be viewed as closely related because, on the one hand, the ultimate reason for conserving and managing archaeological resources is to enhance their research and educational value, while on the other, as more is learned of the nature of archaeological resources, the more sophisticated and responsive can be conservation and management practices.

ONGOING RESEARCH PROBLEMS INVOLVING THE SAN ANTONIO TERRACE

The Vandenberg MX Archaeological Project, in combination with the small amounts of previous research on and in the immediate vicinity of the San Antonio Terrace, provides a small window through which prehistoric events may be viewed. While progress has been made in reconstructing and understanding the prehistory of this portion of the Vandenberg region, it is clear that the archaeological record does not give up its secrets easily. The Vandenberg MX project was devoted to gaining an idea of the subsistence-settlement systems which involved utilization of resources available on the San Antonio Terrace. This research focus was selected not only because the data collected during the project are most amenable to subsistence-settlement studies, but also because knowledge of subsistence-settlement systems provides a foundation upon which a number of other avenues of research can be built. Studies of social and political organization and of economic exchange systems, for instance, generally require that some idea of subsistence and settlement are already in hand. In the end, the Vandenberg MX Archaeological Project was only able to provide a tentative and in some ways crude idea of subsistence-settlement systems involving the use of the San Antonio Terrace, and therefore much of the following discussion of future research directions concerns further study of subsistence and settlement.

The Development of Chronological Measures

Various classes of data collected during the course of the Vandenberg MX Archaeological Project suggest that occupation of the San Antonio Terrace occurred no earlier than 2,000 years ago and that possibly two periods of occupation can be differentiated. However, comparatively little confidence can be had in either of these conclusions, and future research could undoubtedly shed more light on the chronology of the prehistoric occupation of the terrace. A program of radiocarbon dating of site components containing charcoal or shellfish remains could be expanded far beyond that accomplished during the course of this project. Many of the sites along the southern edge of the San Antonio Terrace contain shellfish remains in sufficiently high densities to obtain samples of conventional size from relatively small proveniences. So far, only two of the sites in this locale, SBa-706 and -980, have been radiocarbon dated. At somewhat greater cost, it would be possible to obtain dates from very small samples, especially now that radiocarbon isotope dating is becoming increasingly available.

In order to obtain samples for radiocarbon dating, data collection must normally involve unit excavation in sites, or portions of sites, where organic remains are in noticeable quantities. Furthermore, if charcoal is to be collected as a radiocarbon sample, there must be strong indications that it is of cultural rather than natural origin. Evidence of natural fires was encountered in a number of localities in the project area, including within buried incipient soil horizons in the intermediate dunes. However, if a buried site lacking datable material can be associated with a soil horizon containing charcoal, there would certainly be some justification for obtaining a date from this charcoal.

The use of projectile points as time-markers depends upon detailed knowledge of their temporal distributions throughout the Vandenberg regionl and beyond. Much of the available evidence indicating the temporal positions of projectile point types was cited in Chapter 7, but it is possible that research with existing collections from sites in the region occupied by the Chumash would be able to add further clarity to the chronological sequence of projectile point types. The data from the excavations undertaken in connection with Space Transportation System development on south Vandenberg may be especially enlightening. It is also possible that further investigations at San Antonio Terrace sites containing projectile points and material datable by the radiocarbon technique would provide useful information. The relatively dense midden deposits in some of the sites along the southern edge of the terrace, in the vicinity of the mouth of Shuman Canyon, and in the Casmalia Hills would likely contain this combination of data.

Any geological dating of natural charcoal contained in soil horizons within the intermediate dunefield will shed some light on the temporal positions of sites on the intermediate dunes. Specifically, if the beginning of the advance of the intermediate dunes can be ascertained, it would establish a maximum age for any site on or within these dunes.

A final approach to dating site components involves the study of those chemical constituents of cultural deposits that can be demonstrated to have undergone regular change since site abandonment. Chapter 6 presents a study of soils of certain sites in the project area which demonstrates the feasibility of the approach, even though the precision of this study was not sufficient to arrive at explicit chronological conclusions. For this type of study to be more fruitful, chemical analysis of site soils would require the capabilities of a full-scale soils laboratory rather than the use of a portable soils analysis kit such as the one used for the study presented in Chapter 6. This could potentially be a very expensive approach to dating, and the costs and benefits would have to be carefully weighed in consultation with an expert in soil analysis before such a program is initiated in the future.

The Definition of Settlement Structure and Subsistence-Settlement Systems

The analysis of settlement structure presented in Chapter 10 indicated the presence of possibly six settlement types in the project area, which can be grouped into three functional categories, residential bases, overnight camps, and day-use locations. Two settlement structure models were proposed into which these settlement types fit, one in which populations occupying residential bases would use day-use locations while exploiting resources near the bases and overnight camps while exploiting resources at some distance from the bases, and the other in which two temporally different settlement structures account for the variation between settlement types. In the earlier settlement structure, populations did not use residential bases in the project area, but instead made use of a combination of overnight camps and day-use locations, while in the latter settlement structure, populations emphasized the use of day-use locations near the residential bases and made comparatively little use of overnight camps, perhaps only for purposes other than hunting.

The sample on which these alternative conclusions is based, however, is small, both in numbers of sites included in the analysis and the amounts of data from many of the sites. Furthermore, the samples from the sites cannot always be demonstrated to be representative of the whole sites. These problems with the size and quality of the samples could easily be resolved through the use of data collection approaches that are not seriously constrained by the strictures of a impact mitigation program.

First, testing programs should be oriented toward testing the complete site areas in order to discover the full range of variability in the nature and distributions of cultural materials contained within the site. The use of shovel test pits (STPs) can provide valuable information of this sort, and ideally these should be distributed over the site area more or less equally in both areal dimensions. The strategy of increasing the density of STPs where an initial phase of STP sampling revealed the presence of cultural materials at specific locations, as discussed in the field procedures section of Chapter 3, would aid in the identification of areas within sites where greater concentrations of particular classes of items are present.

An improvement over the STP excavation procedure used for the MX project would in rease the quality of information from the STPs. Since STPs vary considerably in volume as a result of varying amounts of sloughing caused by the variable dryness of the dune sand, control over volume excavated could be gained by packing all soil excavated from an STP into buckets of known volume before screening and recording the number of buckets excavated from the STP on the field record form. In this way, relatively accurate volume estimates for each STP could be calculated, and the density estimates of cultural materials would accordingly be more precise. The best time for excavating STPs in the intermediate dunes would be soon after a rain in the early spring. A normal winter's rainfall would have dampened the soil to considerable depth, and the surface soil would still be relatively damp soon after a rain. However, the best conditions for excavations are the worst for screening, especially at 1/4 inch or 1/8 inch mesh, since the damp sand does not pass through the screens easily. Consequently, an optimal time would probably be later in the spring when the sand has dried out sufficiently so as not to impede seriously screening, but has not become so dry that sloughing is a major problem.

In most sites in the project area, the volume of STPs would not be sufficient for accurate estimates of the densities of those classes of cultural items which occur rarely. Unit excavations would be necessary in these instances. These would normally be placed where there are relatively denser concentrations of cultural materials, and it should be noted that there may be more than one such concentration at a site. The number, size, and placement of the units would depend upon the particular characteristics of the site. Generally, smaller and fewer units would be needed where densities of cultural items are relatively high, as in sites classified as residential bases. The strategy of unit excavation would also be affected by whether the investigation of intrasite structure is included as one of the objectives of the excavation. But in the early phases of investigation of settlement structure, this would probably not be the case.

The study of settlement structure would ideally involve investigation of the whole range of sites that can be assumed to have been used by a human population. The project area clearly did not include many of the other settlement types produced by populations using the San Antonio Terrace. Specifically, coastal sites and sites within the Casmalia and Purisima Hills were not investigated. While a research program would have to be large indeed if the full range of settlement types present on the San Antonio Terrace and its immediate environs were included in the investigations, future research could at least focus on those zones where other kinds of settlement types would be expected.

The hypothesized change in settlement structure mentioned above could possibly be a response to environmental change, as discussed in Chapter 10. Little could be accomplished in the course of the project to discover the nature and magnitude of environmental change during prehistory. The palynology pilot study did not result in the discovery of deposits containing

fossil pollen stretching back into prehistory, and the study of soils and geomorphology of the San Antonio Terrace, presented in Chapter 4, was only able to document the existence of several distinct episodes of dune activity, the two most recent probably occurring within the last 2,000 years. Two avenues of research on or near the San Antonio Terrace could potentially yield more specific information on environmental change. In Chapter 4, Johnson mentions that a wetland located just south of the San Antonio Valley on the western extreme of the Purisima Hills (currently the location of the base horse stables) is clearly much older than any of the wetlands in the intermediate dunes, and it may therefore contain fossil pollen extending back to the early Holocene. Even if fossil pollen is poorly preserved, the sedimentary history of this wetland undoubtedly records some of the major environmental events of the Holocene. Therefore, the study of solid sediment cores from this wetland would be one approach to investigating environmental change. Johnson also points out that profiles created in the intermediate dunes by major earth-moving activities such as those which occurred in the construction of the Missile Assembly Building should be investigated by a soils and geomorphology specialist with the purpose of identifying soil horizons containing datable material such as charcoal. Especially important would be the discovery of organic material resting on the old dune surface which had been covered by intermediate dunes. Assuming that the radiocarbon date from organic material represents vegetation (and perhaps animal life as well) at the time of the advance of the intermediate dunes, this event would therefore be dated relatively precisely.

Human population growth or decline within the Vandenberg region would also have significant effects on settlement structure and more generally subsistence-settlement systems. Unfortunately, a tremendous amount of information regarding numbers of sites and the nature of their contents, as well as detailed chronological information, would be necessary before reasonably precise estimates could be generated. As a result, specific consideration of the impact of population growth and decline would probably have to wait until a relatively large amount of regional research has been accomplished. This does not mean, however, that the possible role of population growth and decline in cultural development should be completely neglected in the meantime. It is possible that some indicators of population fluctuation might be encountered in evidence of food resource exploitation. For instance, Serena points out in the shellfish remains analysis presented in Chapter 9 that marked differences between the prehistoric samples of shellfish remains and the historic sample from SBa-1174 is a result of much greater pressure on shellfish population during the prehistoric period in comparison to that during the historic period. While this particular contrast was quite sharp, subtler differences between the shellfish remains of different prehistoric periods may possibly be related to varying degrees of human pressure on the shellfish population, which in turn could be argued to be a result of fluctuations in human populations density. These kinds of studies which attempt to measure changing human population densities through studies

of food remains require that much is known about the whole subsistence base, since the degree of pressure on a resource may be the result of changes in other aspects of subsistence having little to do with population growth or decline. While it is certainly feasible to produce sufficient amounts of information on subsistence to account for such possibilities, it does imply that considerable amounts of research be accomplished before confident statements about human population fluctuation can be made.

Studies of Intrasite Structure

The research design for the Vandenberg MX Archaeological Project emphasized the potential that studies of intrasite structure could have in isolating discrete episodes of activity in sites located in the intermediate dunes. Because the dunes are not, and have not been, completely stabilized, it is possible that the debris from very short terms of activity, perhaps in some cases transpiring within a part of one day, may become buried and therefore separated by sterile deposits from debris that are either earlier or later in time. At only one site, SBa-1179, excavation was distributed over a large enough area of the site for a study of intrasite structure, although an effort to discern spatial patterns in the course of the analysis of chipped stone (see Chapter 9) was not particularly revealing. Nonetheless, other sites stand a high likelihood of encountering discrete activity areas occurring over very short periods of time, and future research should certainly take advantage of the possibility of discovering the functional associations between different classes of cultural items in such activity areas when they are encountered.

Excavation of sites such as SBa-1179 or of sites representing even more discrete episodes of activity should proceed areally in a gridded block exposure, and if site soils consist of loose sand, the depth of exposure should remain constant over the whole area of the block as excavation proceeds. Furthermore, the edges of the exposure should continually be stepped back so as to eliminate the possibility of sidewall sloughing into the excavation units. In some situations, point provenience information should be collected for every item over about 2 or 3 cm in length. This would be especially important if there is a prospect that refitting of flakes removed from cores and preforms could be an aspect of analysis. Bamforth demonstrated that even at SBa-1179, which apparently represented at least several episodes of activity, some refitting was possible.

Studies of Chipped Stone Artifacts

Chipped stone tools and knapping debris are often the most abundant class of cultural items encountered at sites on the San Antonio Terrace. It is logical, therefore, that considerable effort be made to maximize the amount and diversity of information that can be derived from the study of these items. The analysis of chipped stone artifacts presented in Chapter 9 clearly demonstrates the variety of different kinds of information that can be derived from the suite of analytical approaches available today. The analysis was

hampered, however, by the small and often nonrepresentative samples of lithics from sites included in the analysis, and an important aspect of future research should be to collect samples large enough so that the different analytical approaches can all be fruitfully applied. In particular, it would be very worthwhile to have larger site samples of tools with identifiable edge wear so that the full range of site activities involving the use of chipped stone tools can be identified and their relative importances estimated.

ARCHAEOLOGICAL RESEARCH FOR MITIGATION OF LAND DEVELOPMENT IMPACTS

There are a variety of ways in which projects of the type characterized by the Vandenberg MX Archaeological Project could be improved so as to mesh archaeological investigations more smoothly with construction activities and to improve the quality of the research. The recommendations presented below have been developed out of the experiences gained in the course of the project and refer most specifically to projects of approximately the same scope that might take place on the San Antonio Terrace.

First, survey for the purpose of discovering archaeological resources that might be affected by construction activities would be most efficiently carried out as one episode of activity at the very beginning of the project over a continuous block of land that includes all potential construction areas as well as a surrounding buffer area to allow for changes in construction areas. In this way, detailed information on the locations of cultural resources would be in hand during construction planning stages, and avoidance of archaeological resources as a mitigation measure could be implemented without the necessity of repeated revisions to construction plans as successive surveys of prospective alternate construction locations encounter additional cultural resources. Furthermore, a systematic intensive survey of a large continuous block of land would produce a much more meaningful body of data for research purposes in that variations in the densities of cultural remains throughout the project area can be ascertained with considerable accuracy. In essence, this approach to survey was the one used in the 1974 survey on south Vandenberg in connection with the Space Transportation System development (Spanne and Glassow 1974; Glassow et al. 1976), and it worked very effectively in developing construction plans that minimized impacts to archaeological sites. Some cost savings would undoubtedly result in planning the survey in this way in that less effort would be devoted to both construction planning and archaeological survey than was the case for the Vandenburg MX Archaeological Project.

The quality and usefulness of survey data would also be enhanced if essentially the same procedures were used over the whole survey block as defined above. These procedures would consist of a series of hierarchically ordered steps that would be implemented depending upon the nature of archaeological resources encountered. Survey on recent, intermediate, and old dune surfaces of the San Antonio Terrace must involve both surface and

subsurface observation because of the problem of resources often being buried under thin mantles of sand. The survey would best be undertaken as a series of closely spaced transects starting at one end of the survey block and proceeding to the other end. Ideally, the parallel transects would be no more than 25 m apart, and STPs would be excavated at 25 m intervals along each transect where the transect does not cross wetlands and where cultural items visible on the surface are more than 25 m apart and do not form concentrations that can be defined as sites on surface evidence alone. Orientation of the transects and the intervals between STPs could be maintained by placing control transects established with a survey instrument such as a transit at 125-m intervals. Along these, STP locations would be taped to datums established at intervals appropriate to the topography and the lengths of the transects along which STPs occur. Two transects on either side of the control transects would be maintained by periodic measurement and triangulation from points along the control transects. While this survey procedure may seem to be quite labor-consuming, it would not require much more effort, if any, than was expended during piecemeal surveys carried out during the Vandenberg MX Archaeological Project.

When cultural resources are encountered, either as surface isolates or in STPs, another set of procedures would come into operation in order to establish whether or not a site is present, and if so, the extent of its boundaries. These procedures would resemble those used in the communications lines surveys and the eastern shelters block survey. That is, STPs would be excavated in cross transects out from the location of the find starting at about 10 m intervals, but being reduced to 5 m intervals between an STP containing cultural items and the next lacking items.

Once it has been determined which sites might be impacted by construction, testing with STPs would be undertaken to determine the nature and extent of impacts. It would be extremely helpful for research purposes if comparable procedures were used at each site subjected to testing. One aspect of the testing should be devoted to defining the whole perimeter of the site, not just that portion within the zone of impact. This procedure is justified as a means of determining the extent of impact to the site as a whole, i.e., the percentage of the site to be impacted and the location of the impacts in relation to the gross spatial structure of the site. This type of testing could be of the cross-transect type, but the use of a grid would provide more information on the two-dimensional spatial structure of the site and would therefore be favored. Ideally, the intervals between STP tests would be the same at all sites so that sampling proportions remain constant, but sites with relatively low densities of cultural items might more appropriately be tested with more closely spaced STPs than sites with higher densities.

Unit excavation occurred as both an expansion of testing programs with STPs and a mitigation measure in the course of the Vandenberg MX Archaeological Project, and this dual use of unit excavations continues to be valid. In both instances, the placement of units is governed by the location

of impacts, and there is therefore the unavoidable prospect that the sample of cultural items obtained from unit excavation could be biased. Ideally, some units should be placed outside the area of impact in order to ascertain more clearly the nature of these biases, a procedure that could be justified as an aspect of assessment or mitigation of impacts. The number of units excavated within the impact zones as a mitigation measure should be determined on the basis of the size of the collection for different aspects of data analysis. In the analysis of chipped stone artifacts presented in Chapter 9 is a consideration of minimum sample sizes of lithics for characterizing site assemblages of stone tools.

Prior to the beginning of the analysis, but after the bulk of the fieldwork is completed, some decisions should be made through collaboration between the contractor and agency archaeologists regarding the level of analysis that is to be carried out for each site collection. It should be recognized at this time that certain analytical approaches might be inappropriate with the data base as a whole or with the data from particular sites in light of variations in the size and quality of the samples from the sites. In essence, this is the time when a regional research design developed for the project or as an aspect of a preexisting base management plan is brought down to the level of what can be accomplished in the course of the analysis, and indeed what the structure of the analysis will be. This approach implies that the methodological aspects of the project research design should be relatively general, defining principally problem domains rather than specific problems.

Even though a given site collection might be inadequate for detailed analysis, it may nevertheless become more useful when combined with additional collections from the same site when these might be obtained at some indefinite time in the future. Therefore, emphasis should be placed on insuring that the collections and record documentation are housed in an appropriate curatorial facility so that this utility can potentially be realized. Actually, it should be recognized that even in instances in which a site collection is adequate for the analyses contemplated, other more sophisticated analyses could undoubtedly be undertaken if the collections were larger. Therefore, the importance of comprehensive documentation supporting the collections and proper curation of the collections cannot be emphasized enough. One of the prominent accomplishments of the Vandenberg MX Archaeological Project was the emphasis given to compilation of supporting data (in the form of "basic data reports") and the effort given to correcting errors and discrepancies in the documentation. These basic procedures developed in the course of this project should be used in the future.

ARCHAEOLOGICAL RESOURCE CONSERVATION CONSIDERATIONS

Any particular archaeological project should ultimately be tied to an overarching program for conservation of archaeological resources which includes mechanisms for maximizing the information obtained from the

resources if they are to be expended. Such a program would be embodied in a cultural resources management plan for the base, and the absence of such a plan makes for difficulties in designing a project such as that in support of the development of MX test facilities. One of the greatest difficulties caused by the absence of a management plan is that research designs for different projects are developed without any necessary coordination between them to insure that each research design contributes toward some clearly recognized long-term research goals. Related to this, the data collected in the course of one project are not necessarily comparable to that collected from another, and in evaluations of site significance there may be considerable variation between projects in how the National Register of Historic Places significance criteria are interpreted. There is also some likelihood of redundant efforts, such as the recent overlap in survey areas between the MX Archaeological Project and a separate project for fuel management planning. With specific regard to conservation of cultural resources, the lack of a management plan endangers resources that may be one of a kind or at least very rare, since these have not been identified, nor is there a mechanism that insures that they would be recognized in the course of specific projects. One important step, therefore, in improving the quality of archaeology undertaken on the base, whether undertaken on a small-scale or large-scale, would be to formulate a cultural resources management plan as soon as possible.

Going hand-in-hand with the development of a cultural resources management plan would be the addition of a trained cultural resources manager (with an M.A. or Ph.D. degree) to the resource management staff of the base. Since the bulk of the cultural resources are archaeological in nature, this person should be an archaeologist, but with some expertise in historic as well as prehistoric resources. Most importantly, this person should be knowledgeable in hunter-gatherer studies in archaeology and should have some understanding and appreciation of the kind of archaeological record encountered in the Vandenberg region or more generally California. It would also be important that the cultural resources manager be able to work effectively with local archaeologists and historians, archaeological and historical societies, and Native Americans, all of whom could likely make contributions to both the development and implementation of the management plan. Indeed, the principal function of the cultural resources manager would be to coordinate the development and implementation of this plan, including working with contractors to develop research designs for specific projects consistent with the management plan.

Another major area of concern in the conservation of cultural resources is the manner in which National Register significance criteria are interpreted. It should be recognized that all cultural resources on the base have at least some research potential and therefore would conceivably be eligible for inclusion on the National Register of Historic Places. This is especially so of resources that are studied for purposes of reconstructing hunter-gatherer subsistence-settlement systems. In this context, the geographic distributions of prehistoric artifacts are important, and variations in the distribution of

individual artifacts within the region, rather than variations in the distributions of sites, is often the focus of observation and analysis (Thomas 1975). It is implied, therefore, that the locations of isolated artifacts found beyond the limits of discrete sites are important data and need to be recorded, for they provide information on the intensity of "nonsite" activities occurring within particular sectors of the environment. On the San Antonio Terrace, for instance, isolated projectile points are sometimes found beyond the limits of sites as traditionally defined, and their presence in a locale reflects directly or indirectly the activity of hunting. It is conceivable that some locales on the terrace contain higher densities of isolated projectile points than others, thus indicating the greater frequency of hunting expeditions in those locales. The artifact as a unit of observation is also important in defining variations in the nature of site boundaries. Near the southern edge of the terrace, sites do not have clear boundaries because low densities of cultural materials connect concentrations of significantly higher densities. However, in the central portion of the terrace, sites tend to be more discrete. This difference between the nature of site boundaries reflects some sort of difference in the nature of land use, and this difference can only be understood if the nature of the low-density scatters of cultural materials between sites is investigated.

In the same light, small sites lacking midden development or much depth of deposits are important to subsistence-settlement studies (Talmage, Chesler, et al. 1977). These sites may represent relatively less activity in a locale in comparison to a functionally equivalent site located elsewhere that is larger and contains denser concentrations of cultural items. Furthermore, small sites may actually represent a settlement type onto themselves, possibly locations where an animal was butchered or game behavior was scrutinized. It is also small sites that have the greatest potential for discovering the functional association between different classes of cultural items.

In conclusion, it is important to recognize that significance evaluation takes place only in the context of specific development projects, where the value of the development and the economic feasibility of impact avoidance are weighed against the importance of potentially impacted cultural resources. The importance of the resources, however, cannot be completely evaluated without considering their relationship to other resources on the base, for a major element of site significance is the research potential the resource has in relation to the research potential of other resources. As mentioned above, the necessity of making such comparative evaluations is a major reason why a cultural resources management plan is needed. Ultimately, however, conservation of cultural resources should extend beyond the process of significance evaluation, for land-altering activities may often be designed so as to avoid completely cultural resources without any additional cost in planning or construction. When this is possible, the cumbersome and potentially costly procedure of assessment of significance of the cultural resources can be avoided.

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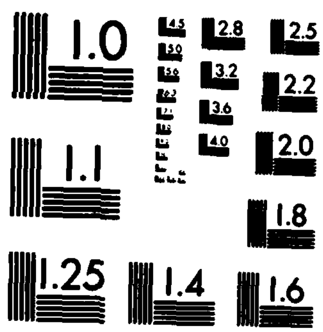

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